NATIONAL EDUCATION COLLABORATION TRUST

education
Department: Education
PROVINCE OF KWAZULU-NATAL

PHYSICALSCIENCE
SCIENCESPHYS

GRADE 12

PHYSICAL SCIENCES

TEACHER TOOLKIT

CAPS Planner

TERM 3

Jika iMfundo
what I do matters

ENDORSED BY
SADTU
NAPTOSA
TEACH WITH DIGNITY
NATU
National Teachers' Union
Educating Our Nation

GRADE 12

Physical Sciences

Teacher Toolkit:
CAPS Planner

TERM 3

Published in 2020 by Jika iMfundo.
Jik'iMfundo is a programme to improve learning outcomes, funded by the National Education Collaboration Trust, the KwaZulu-Natal Department of Education and others.

The Programme to Improve Learning Outcomes (PILO)
The Shed, The Pines, 9 Gordon Hill Road, Parktown, 2193
Tel: + 27 10 880 2431
Email: admin@pilo.co.za

A partnership involving business, civil society, government and labour that strives to improve education outcomes.

The National Education Collaboration Trust
Ground Floor, Block D, Lakefield Office Park, 272 West Avenue, Centurion, 0163
Tel: +27 12 752 6200
Email: info@nect.org.za
Web: www.nect.org.za

ISBN: 978-1-990918-33-9

Materials development by the PILO team along with representatives from the districts and province.

Publishing management by The Word Horse, www.wordhorse.co.za
Design by COMPRESS.dsl, www.compressdsl.com
Typesetting by The Maas Group, www.themaasgroup.com

CONTENTS

CONTENTS

A. INTRODUCTION

This book is intended to help you cover the curriculum for Grade 12 Physical Sciences in Term 3. There is a companion book for Terms 1 and 2 but no planners for Term 4. Teachers should keep these books to use from year to year.

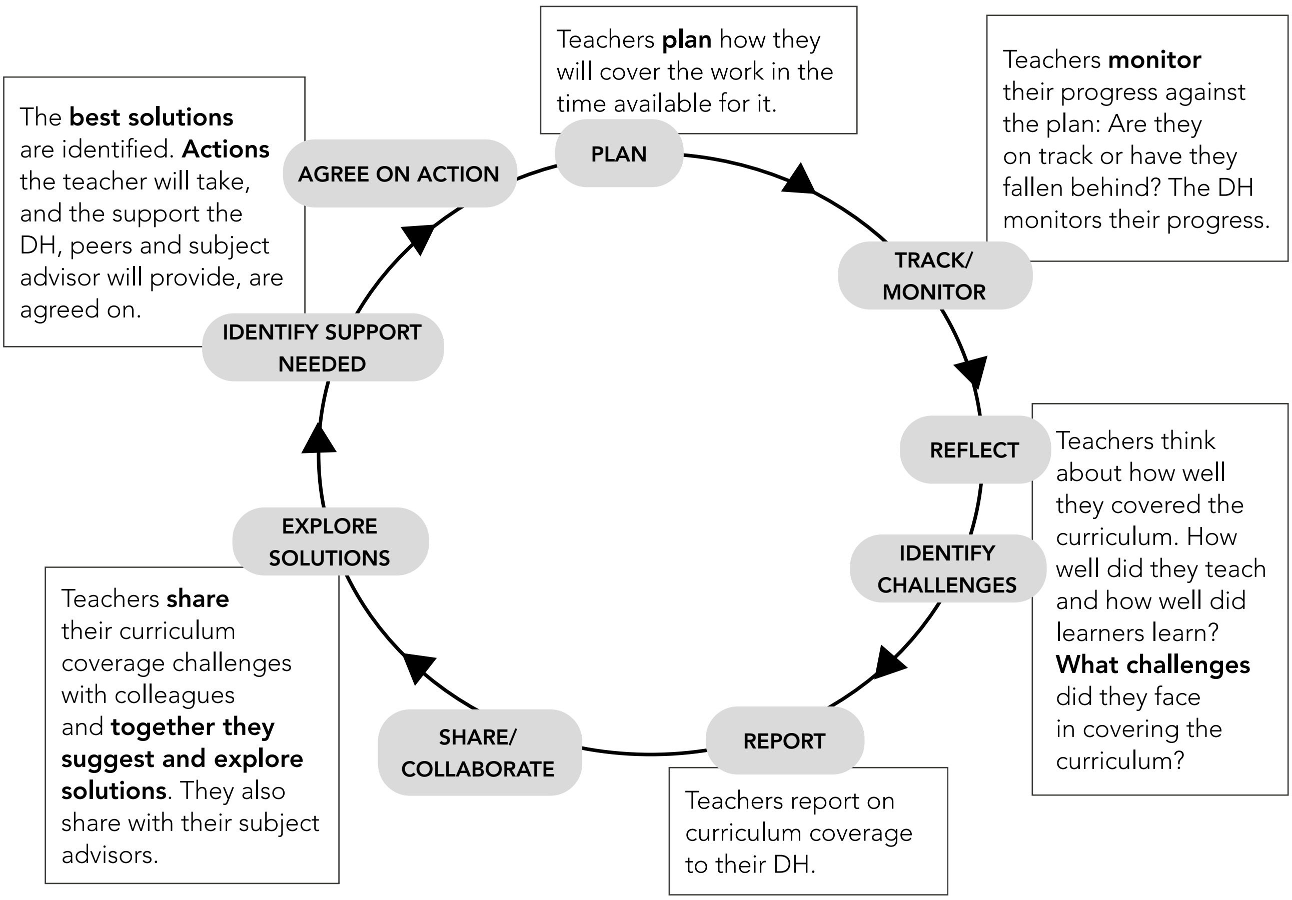
1. The need to improve curriculum coverage

In South Africa, too many learners drop out of school before Grade 12, and too few of those who reach Grade 12 do well in the NSC examinations. There are many reasons for such poor outcomes. One of the most important of these is that the curriculum is not covered each year. In other words, the teachers do not teach everything required by the CAPS in the year, and learners do not sufficiently understand the concepts and develop the skills that are taught. **Improving curriculum coverage is the key thing that teachers can do to improve learning outcomes.**

2. A cycle of activities that support improved curriculum coverage

Covering the curriculum is a complex task in which teachers face many challenges. However, there is a cycle of practices that can support curriculum coverage (see Figure 1). If these practices become routine in the school, curriculum coverage, and thus learners' outcomes, should improve.

Figure 1: The cycle of practices for supporting improved curriculum coverage



B. INFORMATION ABOUT RESOURCES IN THIS BOOK

In this book, you will find resources which will help you plan, track, reflect and report on curriculum coverage for the purpose of working collaboratively with peers and your department head (DH) and subject adviser to solve curriculum coverage problems. The resources are described below.

1. Planners for a daily programme of work

Later in this book there are planners that will help you plan what to teach each day in Term 3 (see Resource 1 in Section C). These planners provide a daily programme of work. There is a planner for all the books on the approved list of Learning and Teaching Support Materials (LTSMs) for Grade 12 Physical Sciences. In addition, each planner includes references to *Everything Science*.

1.1 How planners link to the CAPS

Planners link the CAPS contents and skills to activities in the learner's book (LB) and teacher's guide (TG) of each set of LTSMs. The daily plan of activities ensures that time is allocated to all the work required by the CAPS in the term. Should you miss a lesson for any reason, it is important that you do not skip this lesson, but continue in the next lesson from where you left off.

In the CAPS, four hours have been allocated to Physical Sciences in the FET Phase each week. To meet this specification the planners give the content and skills for four one-hour lessons each week.

1.2 The structure of the planners

The example of a planner below (Table 1) is Week 1 from *Solutions for All Physical Sciences* Term 3. It shows you how the planning for a week is arranged. The same layout, abbreviations and symbols are used in the planners for all the LTSMs for each term.

The table heading states the week of the curriculum and the LTSM to which the planning is linked. It also gives the main content focus for the week. Look at the notes to see what each column tells you.

Table 1: An example of a planner

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 1: Electric circuits							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	**Internal resistance and series and parallel networks** • Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel • State that a real battery has internal resistance • The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf: $\varepsilon = V_{load} + V_{internal\ resistance}$ *or* $\varepsilon = I.R_{ext} + I.r$	129	332–335	CP 1 CP 2	253–293 231–234 238–240	376–389	198
Homework: Check Myself Q. 1–19		129	328–331	Q. 1–19	234–238	385–387	199–211
2	• Solve circuit problems in which the internal resistance of the battery must be considered • Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	335–338 341	CP 3 CP 4 Ex. 9.1 Q. 1–3	240–242 244–245	391–401	211–214
Homework: Ex. 9.1 Q. 4–8		129	342–344	Ex. 9.1 Q. 4–8	245–246	402–405	214–221

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
3	**Experiment: Electric circuits** **Part 1:** Determine the internal resistance of a battery **Part 2:** Set up a series-parallel network with known resistor Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value Resource 8: Worksheet with questions to answer after completing the investigation on electric circuits	129	339–340	Practical	242–244 247–248	389–391	
Resources: **Part 1:** 1,5 V battery, resistor, ammeter, voltmeter, switch, 6 connecting leads **Part 2:** 1,5 V battery, 3 resistors of different values, ammeter, voltmeter, switch, minimum of 7 connecting leads							
Homework: Ex. 9.1 Q. 9–11		129	344	Ex. 9.1 Q. 9–11	247		
4	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	345–346 346–347	Practical EY Q. 1–3	248–251	384–385	
	Set up a series-parallel network with an ammeter in each branch and external circuit and voltmeters across each resistor, branch and battery, position switches in each branch and the external circuit Use this circuit to investigate short circuits and open circuits **Materials:** Battery, connecting wires, several resistors of different values, several voltmeters, several ammeters, switches, a length of low resistance wire						
Homework: EY Q. 4–6		129	347–348	EY Q. 4–6	251–253	376–384	

The columns, from left to right, give the following information:

- The number of the lesson in the week (1–4).
- The CAPS content and skills and practical activities that are dealt with in each lesson.
- The page number in the CAPS where the content referred to is specified.
- The page number in the learner's book where related content and relevant activities can be found.
- The activity in the learner's book that should be done by the learners during the lesson.
- The page number in the teacher's guide where support is given for the work to be done.
- The page number in the *Everything Science* learner's book with related content.
- The page number in the *Everything Science* teacher's guide where supporting material can be found.
- **Note:** Where necessary, particular resources needed for a lesson are shown in the row below the lesson information. Suggestions for homework are also given in this way (see Table 1 Lesson 4, for example).

Abbreviations and symbols used in the planners
Explanation of abbreviations and symbols used in the planners • A Answer • Act. Activity • CA Class activity • Demo. Demonstration • ES *Everything Science* • Ex. Exercise • Exp. Experiment • IA Informal assessment • Inv. Investigation • LB Learner's book • p. Page • PA Practical activity • pp. Pages • Q. Question • S # Hour session • TG Teacher's guide • TYS Test yourself • WS Worksheet

1.3 *How to use the planners*

Plan for the term

- **Find the correct planner to use** – the one that gives the daily plans for the LTSM that you use mostly in your class. You can of course use the others to help you find additional or alternative activities related to the same skills and concepts.
- **Check the length of the term against the number of weeks in the planner.** The school terms are not the same length each year. However, the planner is the same from year to year. The planner for Grade 12 Physical Sciences **Term 3** gives a daily plan for a term of eleven weeks. The content should be covered in the first eight weeks, leaving the last three weeks for revision and the preliminary examinations. If the term in any year is of a different length, or if your school allocates more or less time for examinations than is in the planner, you will have to adjust your planning accordingly. It is very important to do this planning at the beginning of the term so that you neither rush through the work when you in fact have more time for it than allocated in the planner, nor find that you have followed the pace of the planner, but run out of teaching time.

Plan for lessons

- **Compare your timetable with the number of lessons in the week, and the length of each lesson.** If you do not have four periods of one hour each, you will need to adjust the programme for each lesson in the planner to fit the length and number of your lessons.
- **Plan and prepare for each lesson.** The planners give support for the planning of a programme of work. They do not offer help with detailed lesson planning or preparation.

Planning for a lesson involves drawing up a plan of action. A lesson plan should include an introduction, sequenced content and activities for learners to work on individually or in groups, a conclusion, and homework activities to consolidate the learning of the day or to prepare for the next day's lesson where possible. No lesson plan templates are provided here. You should use the one you prefer or that is specified by your school/subject adviser.

When preparing for a Physical Sciences lesson you should:

- make sure that you understand every aspect of the content knowledge and skills addressed in the lesson, and think about common misconceptions learners might hold in relation to the content;
- think carefully about how best to help learners understand new work and develop new skills;
- work through each of the learner activities yourself, noting alternative answers where necessary and making notes on possible learner difficulties in relation to the activities;
- ensure that any resources you need to use in the lesson are available;
- decide how you will pair/group your learners;
- check in your teacher's guide and learner's book for enrichment/challenge activities for learners who have completed their work and/or need a challenge; and
- see where there are remedial and support activities for learners who have barriers to learning.

Please also see Resource 3 in Section C for additional guidelines on planning and preparing a Physical Sciences lesson.

2. Plans for assessment

Curriculum coverage requires teachers to teach the content given in the CAPS each term/year. It also requires that learners understand the concepts and develop the skills that are taught. Thus, assessment gives vital information about how well the curriculum is being covered. It tells teachers which topics or aspects of topics learners are struggling with, and how many learners are managing well, just coping, or struggling. Teachers need to reflect on possible reasons for and implications of these patterns of achievement, thinking about, for example, what they tell of the efficacy of their teaching methodology and how it could be improved, what feedback they can give learners to encourage and support improvement, and whether they can move on to new work, or need to remediate that which has already been taught.

The CAPS requires that teachers assess their learners' progress by means of both informal and formal assessment, and resources in this book assist teachers with planning for both.

2.1 *Informal assessment*

Informal assessment is ongoing and part of the teaching process as teachers listen to learners' responses and questions in class, and check their classwork and homework books. No record of the marks for informal assessment needs to be kept, but recording some of these will help you monitor learners' progress.

The amended Section 4 of the CAPS for Physical Sciences in the FET Phase specifies that two experiments (one for physics, one for chemistry) be assessed informally during the year – one in Term 1 and the other in

Term 3. Note that the choice of experiment to assess informally in Term 3 will be influenced by the choice made in Term 1, so it is advisable to decide which experiment to assess in each term at the beginning of the year. If this choice is specified in the ATP or other official documents, you should of course follow the stipulations given there.

2.2 Formal assessment

Formal assessment is assessment for which marks are recorded. In South African schools, these marks should be entered into SA-SAMS.

It is essential that you plan when your learners will complete formal assessment tasks. Knowing this helps you to plan related activities such as when tasks and marking guidelines will be moderated, when marking will be completed and moderated, when marks will be recorded, and when feedback will be given to learners. All these activities are important in ensuring that assessment is at the correct level and that information from it can be used to support improved curriculum coverage.

Formal assessment tasks specified in the CAPS

The amended Section 4 of the CAPS specifies two formal assessment tasks for Term 3.[1] These are an experiment – either physics or chemistry – and an examination. Please note that the choice of which experiment to assess formally is related to the choice in Term 1 as one physics and one chemistry experiment must be assessed formally altogether. As with the informally assessed experiments, it is advisable to make the decisions about which experiment to assess in Term 1 and which in Term 3 at the start of the year. And, again, if the ATP or other official documents specify what should be done, the stipulations given there must be adhered to.

Formal and informal assessment programmes in the LTSMs and planners

Resources in Section C shows how possible formal and informal assessment tasks are integrated into the planners for Term 3. They show when these tasks are scheduled in the planner for each of the LTSMs. A note is also made of this date in the planners themselves by writing **Experiment** in the CAPS content column. You will see an example of this in Table 1 in Lesson 3.

This table should assist you with your planning for assessment.

Note: The amended Section 4 specifications for Grade 12 come into effect in 2021. In 2020, you should follow the specifications given in the CAPS itself, or in your ATP. In 2020, three experiments are required for formal assessment, and they are prescribed for each of Terms 1 to 3. The prescribed experiment for Term 3 in the unamended Section 4 of the CAPS is the physics experiment marked by an asterisk (*) in Resource 2 of Section C.

The dates in the assessment programme provided for your LTSM might not suit your context for some reason. You should be sure to check this, and schedule dates that are more appropriate where necessary.

3. Resources to support content knowledge, pedagogy and assessment

Sound content and pedagogical knowledge and teaching and learning resources enable teachers to support learning, and thus have a positive impact on curriculum coverage. For this reason, where appropriate, guidelines for teaching certain topics or skills, explanatory information about the content, suggestions for sound structuring of lessons and exemplar assessment tasks are provided in this series of books. The resources in this book are described below:

3.1 Guidelines for lesson planning and preparation

Section 1.3 above drew attention to the need for thorough preparation for a Physical Sciences lesson to be successful and gave some brief pointers for effective preparation. Resource 3 in Section C of this planner gives more detail about the points made in 1.3. It also gives some useful guidelines for practical activities.

3.2 Overview of the Term 3 topics

Resource 4 in Section C provides some broad information about the topics in Term 3 and suggestions of how to help learners deepen their understanding of them, their ability to apply their knowledge in different contexts and to solve problems, and insight into the relevance of what they have learnt.

1 The DBE makes changes to the assessment requirements from time to time. In such instances, you might need to change the assessment programme shown here to align with the revised requirements.

3.3 Additional information and enrichment activities for Term 3

The books on the approved list do not cover all the topics in the CAPS equally. They vary in the explanations and activities provided. For this reason, Resource 5 provides additional information and ideas for activities related to certain topics in Term 3. Some of these fill gaps in one or other of the LTSMs; some serve to extend what is provided. You will see references to the worksheets provided in Resource 6. These are discussed further in Section 3.4 below.

It is important that you look at Resource 5 when doing your planning and preparation so that you can integrate ideas there with those in your LTSMs.

3.4 Additional worksheets with memorandums for Term 3

The worksheets provided (Resource 6) are intended to be photocopied for your learners. They have been included for two purposes. Firstly, they provide learners an opportunity to engage more fully with the specified concepts and skills than is afforded them in some of the LTSMs where there might be little information and no relevant activities. Secondly, they provide extension activities for learners who have completed those in the LTSMs ahead of others and need extra work. There are answers to all the questions in the worksheets to support teachers in working through them with their learners.

3.5 Assessment resources

In addition to the support provided in planning for assessment (see Resource 2), this book also provides some assessment materials and a tool for item analysis. These are described below.

3.5.1 An exemplar worksheet and memorandum for the physics experiment on electric circuits

This is a clearly laid out worksheet that could be done by learners who have done the experiment on electric circuits as the formal assessment experiment for Term 3. It is accompanied by a detailed memorandum (see Resources 7 and 8).

3.5.2 Exemplar item analysis sheets for Term 3 formal assessment

Resources 9.1, 9.2 and 9.3 provide blank templates which you can copy and use to fill in your learners' names and the marks each achieved for the questions in the physics and chemistry examinations or the skills in the investigations/practical tasks.

Resources mentioned in 3.5.1 and 3.5.2 above support curriculum coverage by:

- providing a worksheet that will encourage learners to think more deeply about what they have learnt in doing an experiment. The memorandum supports teachers in marking this work and helps ensure that marking will be to the same standard across different markers. The marks for this worksheet could be used as part of the mark for the experiment. In this case, it should be answered under controlled conditions; and
- encouraging teachers to do an item analysis of the preliminary examination papers written by learners to identify where learners' strengths and weaknesses are. This enables them to focus remediation on topics and skills where it is most needed by the class as a whole or by individual learners.

3.6 A template for tracking, reflecting and reporting for collaborative problem solving

Planning is one activity on the curriculum completion support cycle (Figure 1), and you have seen how the material in this book supports teachers with planning. The templates provided as Resource 10 in Section C are tools to assist teachers with other aspects of the cycle. There is a template to use in conventional schools, and one for use in multigrade schools. The template for conventional schools is reproduced on the following page, with annotations that show how it is used as a tool for curriculum coverage support. The template for multigrade schools works in the same way.

Teachers should print a copy of the relevant template for each week of the term and use it together with the teaching plan for that week. This teaching plan could be the planner for their LTSM in this book or the ATP or another daily planning resource. They record curriculum coverage information and their reflection on it for all the Physical Sciences lessons with each class they teach in the week.

Note that dates are not given in the tracking and reflecting template. Teachers should fill two dates into the spaces at the top of the template. Firstly, they should record the week in the planner when the work they are doing is scheduled to be done; secondly, they should record the week when they in fact are starting that work. These dates will help them see how well they are keeping up with the pace set in the planner they are following.

This is the no. of the week in the planner that is being followed.

This is the no. of the week in the term when the work actually starts. If curriculum coverage is behind, this might be a later week than the week in the planner.

Week no. in planner _______________

Week no. in term when work planned for week started _______________

Refer to the planner for details of the week's work (or the ATP for subjects without planners)

Class (or subject for FP)				
On track by end of week? (Yes/no)				
How many learners are working confidently? (Rough estimate)				
How many learners in this class?				

At the end of the week, the teacher uses evidence from informal and formal assessment, to estimate for each class how many learners out of the total are working confidently at Level 4 or above. They use this information, together with the amount of work planned that they have taught, to state whether or not their curriculum coverage is on track.

Prompts for daily reflection.

DAY	**BRIEF NOTES ON THE DAY'S WORK: Consider such things as:** *What concepts/skills did the learners struggle with or manage well in this lesson? What could be the reasons for this? Did the class complete the work you had planned? Do you need to change your plans for the next lesson? What changes will you make?*
1	
2	
3	
4	
5	

Each day, the teacher reflects on how their lesson went, and how they could improve it using the prompts provided. They also think about whether or not they can proceed as planned in the next lesson. This is a professional judgement they make based on informal and formal assessment. They note the main points here.

Reflection on the week:	
What concepts and skills for the week did learners struggle with? What could you do differently next time to better support or extend learning? What good practice could you share?	**Did you cover the curriculum for the week? If not, what were some of the challenges? What can you do to catch up? What help do you need? How will your progress this week affect your plan for next week?**
DH:	**Date:**

At the end of the week, the teacher reflects on the week's teaching and learning. They think about what learners found difficult, and how they can change their practice so learning improves.

At the end of the week, the teacher considers whether or not the work planned for the week has been taught and learnt, and if not, what can be done to solve curriculum coverage problems and get back on track.

The teacher writes their reflections here for their own professional development, but also to share them with their DH to get support in solving problems.

At the end of the week, the DH reads the teacher's reflections and record of curriculum coverage and signs the template. S/he uses the information shared in a supportive conversation with the teacher. Together they consider any curriculum coverage problems the teacher faces and work towards finding solutions.

1. PLANNERS FOR TERM 3

1.1 *Solutions for All Physical Sciences* (Macmillan South Africa)

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 1: Electric circuits							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	**Internal resistance and series and parallel networks** • Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel • State that a real battery has internal resistance • The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf: $\varepsilon = V_{load} + V_{internal\ resistance}$ *or* $\varepsilon = I.R_{ext} + I.r$	129	332–335	CP 1 CP 2	253–293 231–234 238–240	376–389	198
Homework: Check Myself Q. 1–19		129	328–331	Q. 1–19	234–238	385–387	199–211
2	• Solve circuit problems in which the internal resistance of the battery must be considered • Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	335–338 341	CP 3 CP 4 Ex. 9.1 Q. 1–3	240–242 244–245	391–401	211–214
Homework: Ex. 9.1 Q. 4–8		129	342–344	Ex. 9.1 Q. 4–8	245–246	402–405	214–221
3	**Experiment: Electric circuits** **Part 1:** Determine the internal resistance of a battery **Part 2:** Set up a series-parallel network with known resistor Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value Resource 8: Worksheet with questions to answer after completing the investigation on electric circuits	129	339–340	Practical	242–244 247–248	389–391	
Resources: **Part 1:** 1,5 V battery, resistor, ammeter, voltmeter, switch, 6 connecting leads **Part 2:** 1,5 V battery, 3 resistors of different values, ammeter, voltmeter, switch, minimum of 7 connecting leads							
Homework: Ex. 9.1 Q. 9–11		129	344	Ex. 9.1 Q. 9–11	247		
4	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	345–346 346–347	Practical EY Q. 1–3	248–251	384–385	
	Set up a series-parallel network with an ammeter in each branch and external circuit and voltmeters across each resistor, branch and battery, position switches in each branch and the external circuit Use this circuit to investigate short circuits and open circuits **Materials:** Battery, connecting wires, several resistors of different values, several voltmeters, several ammeters, switches, a length of low resistance wire						
Homework: EY Q. 4–6		129	347–348	EY Q. 4–6	251–253	376–384	

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 2: Electrodynamics							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	**Electrical machines (generators, motors)** • State that generators convert mechanical energy to electrical energy and motors convert electrical energy to mechanical energy • Use Faraday's Law to explain why a current is induced in a coil that is rotated in a magnetic field	130	352–362	CP 1 CP 2	293–299	408–412	224
Resources: https://www.youtube.com/watch?v=gQyamjPrw-U							
Homework: Ex. 10.1 Q. 1–5			364–365		300–303	408–412	
2	• Use words and pictures to explain the basic principle of an AC generator (alternator) in which a coil is mechanically rotated in a magnetic field • Use words and pictures to explain how a DC generator works and how it differs from an AC generator • Give examples of the use of AC and DC generators	130	359–368		304		
Resources: https://www.youtube.com/watch?v=gQyamjPrw-U							
Homework: Ex. 10.2 Q. 1–7			369		305–307	415 Q. 1–4	224–225
3	• Explain why a current-carrying coil placed in a magnetic field (but not parallel to the field) will turn by referring to the force exerted on moving charges by a magnetic field and the torque on the coil • Use words and pictures to explain the basic principle of an electric motor • Give examples of the use of motors	130	370–375	CP 3 CP 4	307–309	412–415	
Resources: Electric motor simulation http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/laplace_lorentz_force_electric_motor_principle_brushes_split_ring.htm							
Homework: Ex. 10.3 Q. 1–9			376–379		310–313	415 Q. 5–8	224–225
4	**Alternating current** • Explain the advantages of alternating current • Write expressions for the current and voltage in an AC circuit • Define the rms (root mean square) values for current and voltage as: $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ *and* $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ respectively, and explain why these values are useful • Know that the average power is given by: $P_{av} = I_{rms}V_{rms} = \frac{1}{2}I_{max}V_{max}$ for a purely resistive circuit • Draw a graph of voltage vs time and current vs time for an AC circuit		380–383	CP 5 CP 6	313–315	416–422	
Homework: Ex. 10.4 Q. 1–3		131	383–384		315	418–419	225–227
	Project: Build a simple electric generator Build a simple electric motor **Materials:** Enamel-coated copper wire, 4 large ceramic block magnets, cardboard (packaging), large nail, 1.5 V 25 mA light bulb, 9 V cell						

<table>
<tr><th colspan="8">SOLUTIONS FOR ALL PHYSICAL SCIENCES
Week 3: Electrodynamics, optical phenomena and properties of materials</th></tr>
<tr><th rowspan="2">S #</th><th rowspan="2">CAPS concepts, practical activities and assessment tasks</th><th rowspan="2">CAPS pp.</th><th rowspan="2">LB pp.</th><th rowspan="2">LB act.</th><th rowspan="2">TG pp.</th><th colspan="2">Everything Science</th></tr>
<tr><th>LB</th><th>TG</th></tr>
<tr><td>1</td><td>• Solve problems using the concepts of:
I_{rms}
V_{rms}
P_{av}</td><td>131</td><td>383–385</td><td>Ex. 10.4
Q. 4–10</td><td>315–319</td><td>419–422</td><td></td></tr>
<tr><td colspan="2">Homework: EY Q. 1–4</td><td></td><td>389–390</td><td>EY
Q. 1–4</td><td>321–323</td><td>423</td><td>227–229</td></tr>
<tr><td>2</td><td>Advantages of using AC current</td><td>131</td><td>386–388</td><td>Ex. 10.5
Q. 1–5</td><td>319–321</td><td></td><td></td></tr>
<tr><td colspan="2">Homework: EY Q. 5–9</td><td></td><td>389–390
390–391
396–397</td><td>EY
Q. 5–9</td><td>323–325</td><td></td><td></td></tr>
<tr><td rowspan="2">3</td><td>• Photoelectric effect
• Describe the photoelectric effect as the process that occurs when light shines on a metal and it ejects electrons
• Give the significance of the photoelectric effect:
– it establishes the quantum theory
– it illustrates the particle nature of light
• Define cut-off frequency, f_o</td><td>132–133</td><td>398–403</td><td>Practical demon-stration</td><td>326–330</td><td>426–429</td><td>232</td></tr>
<tr><td colspan="7">Demonstration: Photoelectric effect
Materials: Gold leaf electroscope, zinc plate, UV lamp (see Resource 5 of this planner)
Mercury discharge lamp, photosensitive vacuum tube, set of light filters, circuit to produce retarding voltage across phototube, oscilloscope, ammeter</td></tr>
<tr><td colspan="8">Resources: https://phet.colorado.edu/sims/photoelectric/photoelectric_en.jnlp</td></tr>
<tr><td colspan="2">Homework: Read and make short notes on pp. 398–403</td><td></td><td>398–403</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>• Define work function and know that the work function is material-specific
• Know that the cut-off frequency corresponds to a maximum wavelength
• Apply the photoelectric equation:
$E = W_o + KE_{max}$ where $E = hf$, $W_o = hf_o$ and
$KE_{max} = \frac{1}{2}mv^2_{max}$
• Know that the number of electrons ejected per second increases with the intensity of the incident radiation</td><td>132–133</td><td>404–409</td><td>CP1
CP2
CP3
CP4</td><td>330–332</td><td>428–434</td><td>233</td></tr>
<tr><td colspan="2">Homework: Ex. 11.1 Q. 1–4
Alternative homework: Resource 6: Worksheet 1</td><td></td><td>412–413</td><td></td><td>333–334</td><td>434–435
Ex. 12.1
1–2</td><td>233</td></tr>
</table>

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 4: Optical phenomena and properties of materials, electrochemical reactions							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	• Know that if the frequency of the incident radiation is below the cut-off frequency, then increasing the intensity of the radiation has no effect, i.e. it does not cause electrons to be ejected • Understand that the photoelectric effect demonstrates the particle nature of light	132–132	409–415	Ex. 11.1 Q. 5–10	335–337	434–435 Ex. 12.1 3–5	233–235
Homework: EY Q. 1–3			427–428		343–345	441 Ex. 12.3 1–2	236–237
2	**Emission and absorption spectra** • Explain the source of atomic emission spectra (of discharge tubes) and their unique relationship to each element • Relate the lines on the atomic spectrum to electron transitions between energy levels	133	416–421	CP 5	337–339	435–437	235–236
Homework: Ex. 11.2 Q. 1–5		133	422		339–340	Ex. 12.2 1, 2, 5	235–236
3	• Explain the difference between atomic absorption and emission spectra • Application to astronomy		423–426	CP 6 Ex. 11.3 Q. 1–5	340–343	437–441	235–236
Homework: EY Q. 4–5			428–430		345	Ex. 12.2 3, 4, 6	235–236
4	**Electrolytic cells and galvanic cells** • Define oxidation and reduction in terms of electron (e-) transfer • Define oxidising agent and reducing agent in terms of oxidation and reduction	134	432–438	Practical (recom-mended)	346–354	444–451	240–242
	Experiment: Investigate the reduction of metal ions and halogens **Materials:** Zinc, lead, aluminium and copper electrodes, zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide, potassium nitrate, four beakers, sandpaper Three test tube racks; 9 large test tubes; solutions of chlorine water, bromine water and iodine water; 0,2 $mol \cdot dm^{-3}$ solutions of halides NaCℓ, NaBr and NaI; non-polar solvent such as xylene or dichloromethane; three droppers; glass stirring rod						
Homework: Complete the report on the practical investigation and answer the questions			434–438		352–354	449 Ex. 13.2 1–2	242–244

SOLUTIONS FOR ALL PHYSICAL SCIENCES	Week 5: Electrochemical reactions						
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	• Define the galvanic cell in terms of: – self-sustaining electrode reactions – conversion of chemical energy to electrical energy • Define anode and cathode in terms of oxidation and reduction		438–441	CP 1 CP 2	354–356	452–455	240–241
Homework: Make summary notes on pp. 438–441			438–441			451 Ex. 13.3 1, 2	244–245
2	• Define the electrolytic cell in terms of: – electrode reactions that are sustained by a supply of electrical energy – conversion of electrical energy into chemical energy		442–443	CP 3 CP 4	356–358	456–457	245–248
Homework: Make summary notes on pp. 442–443						461 Ex. 13.4 Q. 2	246–248
3	**Understanding of the processes and redox reactions taking place in cells** • Describe: – the movement ions through the solutions – the electron flow in the external circuit of the cell – the half-reactions at the electrodes – the function of the salt bridge in galvanic cells • Use cell notation or diagrams to represent a galvanic cell		444–447	CP 5 CP 6	358–360	462–465	248–250
Homework: Ex. 12.1			447		360	464 Ex. 13.5 1–3	248–250
4	**Experiment:** Investigate the electrolysis of water and sodium iodide **Materials:** Water bowl, electrodes for the electrolysis of water, test tubes, conductivity wires, 9 V battery, current indicator (LED), water and sodium iodide and sodium sulphate		448–452		360–363	456–461	
Homework: CP 7			452		363	461–462 Ex. 13.4 1, 3, 4	246–248

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 6: Electrochemical reactions							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	**Standard electrode potentials** • Give the standard conditions under which standard electrode potentials are determined • Describe the standard hydrogen electrode and explain its role as the reference electrode • Explain how standard electrode potentials can be determined using the reference electrode • State the convention regarding positive and negative values		453–456	CP 8	363–366	467–471	250–251
	Experiment: Find the galvanic cell with the highest potential **Materials:** Zinc; lead; aluminium and copper electrodes; solutions of zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide and potassium nitrate; 2 beakers; U-tube; cotton wool; voltmeter; connecting leads						
Homework: CP 8			456		366	471–472 Ex. 13.6 1–4	250–251
2	• Use the Table of Standard Reduction Potentials to calculate the emf of a standard galvanic cell • Use a positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions **Relation of current and potential to rate and equilibrium** • Give and explain the relationship between current in an electrochemical cell and the rate of the reaction • State that the potential difference of the cell (V_{cell}) is related to the extent to which the spontaneous cell reaction has reached equilibrium • State and use the qualitative relationship between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction: • *V_{cell} decreases as the concentration of product ions increases and the concentration of reactant ions decreases until equilibrium is reached at which* • *V_{cell} = 0V (the cell is 'flat')* • (Qualitative treatment only, Nernst equation is NOT required) • Illustrate processes submicroscopically • Le Chatelier's principle can be used to argue the shift in equilibrium		456–459	CP 9 CP 10	366–368	466 472–475	251
Homework: CP 9, CP 10			457		367–368	476 Ex. 13.7 1–3	251–252

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
3	**Writing equations to represent oxidation and reduction half-reactions and redox reactions** • Predict the half-cell in which oxidation will take place when connected to another half-cell • Predict the half-cell in which reduction will take place when connected to another half-cell • Write equations for reactions taking place at the anode and cathode • Deduce the overall cell reaction by combining two half-reactions		460–462	CP 11 Ex. 12.2 Q. 1–3		476–480	252–253
Homework: Ex. 12.2 Q. 4–6			463		371	480 Ex. 13.9 1–4	253–256
4	• Describe, using half-equations and the equation for the overall cell reaction, the following electrolytic processes: – the decomposition of copper chloride – a simple example of electroplating (e.g. the refining of copper)		461–463	CP 12	370	481–482 487–489	259–260
Homework: EY Q. 1–2			472		375	489 Ex. 13.11 1–3	259–260

SOLUTIONS FOR ALL PHYSICAL SCIENCES
Week 7: Electrochemical reactions, the chemical industry

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
1	**Oxidation numbers and application of oxidation numbers** • Revise from Grade 11 and extend in Grade 12 • Describe the electrolytic process used industrially in the recovery of aluminium metal from bauxite: – half-equations and the equation for the overall cell reaction – the layout of the particular cell using a schematic diagram – potential risks to the environment (South Africa uses bauxite from Australia)		466–469	CP 13 CP 14	371–374	487–488 490–491	260–263
Homework: CP 15 EY Q. 4			468 472		374 376	490–491 Ex. 13.11 Q. 4–8	260–263
2	• Describe the electrolytic process used industrially in the production of chlorine (the chemical reactions of the chloroalkali industry): – half-equations and the equation for the overall cell reaction – the layout of the particular cell using a schematic diagram – potential risks to the environment		467–471	CP 16	374	482–486	256–259
Homework: EY Q. 3, 5			472		375–376	486–487 Ex. 13.10 1–4	256–259
3	• **The fertiliser industry (N, P, K)** • List, for plants: – three non-mineral nutrients, i.e. nutrients that are not obtained from the soil: C, H and O and their sources, i.e. the atmosphere (CO_2) and rain (H_2O) – three primary nutrients N, P and K and their source, i.e. the soil • These nutrients are mineral nutrients that dissolve in water in the soil and are absorbed by the roots of plants • Fertilisers are needed because there are not always enough of these nutrients in the soil for healthy growth of plants • Explain the function of N, P and K in plants • Give the sources of N (guano), P (bone meal) and K (German mines) before and after the First World War • Interpret the N:P:K fertiliser ratio • Describe and explain (rates, yields, neutralisation, …), using chemical equations wherever appropriate, the following aspects of the industrial manufacture of fertilisers, given diagrams, flow charts and so on for: – N_2 – fractional distillation of air – H_2 – at SASOL from coal and steam – NH_3 – Haber Process – HNO_3 – Ostwald Process		479–488	CP 1 CP 2 CP 3 CP 4 CP 5	377–383	494–500	266–268
Homework: Ex. 13.1 Q. 1–3			484		381–382	499–500 Ex. 14.1 Q. 1–5	268–269

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
4	• Describe and explain (rates, yields, neutralisation, …), using chemical equations wherever appropriate, the following aspects of the industrial manufacture of fertilisers, given diagrams, flow charts and so on for: – H_2SO_4 – including the Contact Process – H_3PO_4 and $Ca(H_2PO_4)_2$ (superphosphates) – NH_4NO_3 (ammonium nitrate), $(NH_4)_2SO_4$ (ammonium sulfate) and H_2NCONH_2 (urea) • Give sources of potash (mined imported potassium salts like KNO_3, K_2SO_4) • Link SASOL to the production of fertilisers, e.g. ammonium nitrate (fertiliser and explosive)		488–493	CP 6–9 Ex. 13.2	383–384	270–279	
Homework: Resource 6 Worksheet 4: Chemical industries (fertilisers)			480 493	WS 4		WS 4 memo	

SOLUTIONS FOR ALL PHYSICAL SCIENCES Week 8: The chemical industry

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
1	• Discuss advantages of inorganic fertilisers • Discuss alternatives to inorganic fertilisers (IKS) • Define eutrophication • Discuss how the public can help to prevent eutrophication • Keep the details in this section limited to applications • Evaluate the use of inorganic fertilisers on humans and the environment • Discuss alternatives to inorganic fertilisers as used by some communities • (Knowledge of eutrophication is expected)		494–497	CP 10 CP 11	385–386	500–505	280–281
Homework: Ex. 13.3 Q. 1–3			497		387–388	506–512	
2	• The quality of water sources in the country has been on the news a lot in our country • Rivers used to be clean sources of water • Do an investigation on the causes of this high pollution of rivers near you • Assess how many people rely on fertilisers for their gardens in your area • Assess whether the use of inorganic fertilisers has increased • Research if this can be related to the quality of water in the river near your village, town or city		498–499	EY Q. 1–6	388–389	506–512	282–284
3	**Revision**						
4	**Revision**						

SOLUTIONS FOR ALL PHYSICAL SCIENCES Weeks 9–11: Preliminary examinations

1.2 *Study and Master Physical Sciences* (Cambridge University Press)

STUDY AND MASTER PHYSICAL SCIENCES Week 1: Electric circuits							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	**Internal resistance and series and parallel networks** • Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel • State that a real battery has internal resistance • The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf: $\varepsilon = V_{load} + V_{internal\ resistance}$ *or* $\varepsilon = I.R_{ext} + I.r$	129	260–265	ES Ex. 10.1 Q. 1–8 TY 1 Q. 1–3	D70	376–391	198–211
Homework: *ES Ex. 10.2 Q. 1–7		129	*ES 391–392		*ES 211–214	391–392	211–214
2	• Solve circuit problems in which the internal resistance of the battery must be considered • Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	265–267	TY 2 Q. 1–2	D70–D71	392–401	
Homework: *ES Ex. 10.3 Q. 1–6		129	*ES 403–405		*ES 214–221	402–405	214–221
3	**Experiment: Electric circuits** **Part 1:** Determine the internal resistance of a battery **Part 2:** Set up a series-parallel network with known resistor Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value Resource 6: Worksheet with questions to answer after completing the investigation on electric circuits	129	267–269	Act. 1	D71–D73	389–391	
Resources **Part 1:** 1,5 V battery, resistor, ammeter, voltmeter, switch, 6 connecting leads **Part 2:** 1,5 V battery, 3 resistors of different values, ammeter, voltmeter, switch, minimum of 7 connecting leads							
Homework: SA Q. 3–7		129	301–302		D79–D80		
4	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	129	270–275	Act. 2	D73–D75	384–385	
	Set up a series-parallel network with an ammeter in each branch and external circuit and voltmeters across each resistor, branch and battery, position switches in each branch and the external circuit Use this circuit to investigate short circuits and open circuits **Materials:** Battery, connecting wires, several resistors of different values, several voltmeters, several ammeters, switches, a length of low resistance wire						
Homework: Act. 3 Q. 1–2		129	275		D75–D76	376–384	

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science* LB	*Everything Science* TG
	STUDY AND MASTER PHYSICAL SCIENCES Week 2: Electrodynamics						
1	**Electrical machines (generators, motors)** • State that generators convert mechanical energy to electrical energy and motors convert electrical energy to mechanical energy • Use Faraday's Law to explain why a current is induced in a coil that is rotated in a magnetic field	130	276–281			408–412	224
Resources: https://www.youtube.com/watch?v=gQyamjPrw-U							
Homework: TY 3 Q. 1–3			283		D76	408–412	
2	• Use words and pictures to explain the basic principle of an AC generator (alternator) in which a coil is mechanically rotated in a magnetic field • Use words and pictures to explain how a DC generator works and how it differs from an AC generator • Give examples of the use of AC and DC generators	130	281–284				
Resources: https://www.youtube.com/watch?v=gQyamjPrw-U							
Homework: TY 3 Q. 3–5			283		D76	415 Q. 1–4	224–225
3	• Explain why a current-carrying coil placed in a magnetic field (but not parallel to the field) will turn, by referring to the force exerted on moving charges by a magnetic field and the torque on the coil • Use words and pictures to explain the basic principle of an electric motor • Give examples of the use of motors	130	284–291	TY 4 Q. 1–4 Act. 6 1–8	D76 D77–D78	412–415	
Resources: Electric motor simulation http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/laplace_lorentz_force_electric_motor_principle_brushes_split_ring.htm							
Homework: SA Q. 1–2; *ES Ex. 11.1 Q. 1–8		130	299–300 *ES 415		D79 *ES 224–225	415 Q. 5–8	224–225
4	**Alternating current** • Explain the advantages of alternating current • Write expressions for the current and voltage in an AC circuit • Define the rms (root mean square) values for current and voltage as: $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ *and* $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ respectively, and explain why these values are useful • Know that the average power is given by: $P_{av} = I_{rms}V_{rms} = \frac{1}{2}I_{max}V_{max}$ for a purely resistive circuit • Draw a graph of voltage vs time and current vs time for an AC circuit	131	291–298	Act. 7	D78–D79	416–422	
Homework: SA Q. 8–11		131	302–303		D80–D82	418–419	225–227
	Project: Build a simple electric generator Build a simple electric motor **Materials:** Enamel-coated copper wire, 4 large ceramic block magnets, cardboard (packaging), large nail, 1.5 V 25 mA light bulb, 9 V cell						

STUDY AND MASTER PHYSICAL SCIENCES

Week 3: Electrodynamics, optical phenomena and properties of materials

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
1	• Solve problems using the concepts: I_{rms} V_{rms} P_{av}	131				419–422	
Homework: *ES Ex. 11.2 Q. 1–9		131	*ES 418–419		*ES 225–227	423	227–229
2	Advantages of using AC current	131	*ES 423	*ES Ex. 11.3 Q. 1–7	*ES 227–229		
Homework: Revise and learn all the work on Electrodynamics		131	260–303				
3	**Photoelectric effect** • Describe the photoelectric effect as the process that occurs when light shines on a metal and it ejects electrons • Give the significance of the photoelectric effect: – it establishes the quantum theory – it illustrates the particle nature of light • Define cut-off frequency, f_o	132–133	304–309		D84	426–429	232
	Demonstrations: Photoelectric effect **Materials:** Gold leaf electroscope, zinc plate, UV lamp Mercury discharge lamp, photosensitive vacuum tube, set of light filters, circuit to produce retarding voltage across phototube, oscilloscope, ammeter						
Homework: TY 8 Q. 1–3			309–310		D84		
4	• Define work function and know that the work function is material-specific • Know that the cut-off frequency corresponds to a maximum wavelength • Apply the photoelectric equation: $E = W_o + KE_{max}$ where $E = hf$, $W_o = hf_o$ and $KE_{max} = \frac{1}{2}mv^2_{max}$ • Know that the number of electrons ejected per second increases with the intensity of the incident radiation	132–133	310–314		D84	428–434	233
Resources: https://phet.colorado.edu/sims/photoelectric/photoelectric_en.jnlp							
Homework: TY 9 Q. 1–2 Alternative homework: Resource 6: Worksheet 1			314	WS 1	D84 WS 1 memo	434–435 Ex. 12.1 1–2	233

STUDY AND MASTER PHYSICAL SCIENCES
Week 4: Optical phenomena and properties of materials, electrochemical reactions

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	TG
1	• Know that if the frequency of the incident radiation is below the cut-off frequency, then increasing the intensity of the radiation has no effect, i.e. it does not cause electrons to be ejected • Understand that the photoelectric effect demonstrates the particle nature of light	132	321–322	SA Q. 4–8	D85–D87	434–435 Ex. 12.1 3–5	233–235
Homework: Make summary notes on the photoelectric effect; Resource 6: Worksheets 2 and 3		132	304–314	WS 2–3	WS 2–3 and memos	441 Ex. 12.3 1–2	236–237
2	**Emission and absorption spectra** • Explain the source of atomic emission spectra (of discharge tubes) and their unique relationship to each element • Relate the lines on the atomic spectrum to electron transitions between energy levels	133	314–318			435–437	235–236
Homework: SA Q. 1–3		133	320–321		D85	Ex. 12.2 1, 2, 5	235–236
3	• Explain the difference between atomic absorption and emission spectra • Application to astronomy	133	318–319	TY 10 Q. 1–2	D85	437–441	235–236
Homework: SA Q. 9–11		133	322		D87	Ex. 12.2 3, 4, 6	235–236
4	**Electrolytic cells and galvanic cells** • Define oxidation and reduction in terms of electron (e-) transfer • Define oxidising agent and reducing agent in terms of oxidation and reduction	134	323	Informal practical	D88–D89	444–449 470–471	240–242
	Experiment: Find the galvanic cell with the highest potential **Materials:** Zinc, lead, aluminium and copper electrodes; solutions of zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide and potassium nitrate; 2 beakers; U-tube; cotton wool; voltmeter; connecting leads		325–326		D89		
Homework: Complete the report on the practical investigation and answer the questions; *ES Ex. 13.1 Q. 1–2		134	*ES 445		*ES 241–242	449 Ex. 13.2 1–2	242–244

STUDY AND MASTER PHYSICAL SCIENCES Week 5: Electrochemical reactions

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science* LB	*Everything Science* TG
1	**Experiment:** Investigate the electrolysis of water and sodium iodide Investigate the reduction of metal ions and halogens	134	326–328	Informal practical	D89–D91	458–461 474–475	240–241
	Materials for the electrolysis of water: Water bowl, two electrodes for the electrolysis of water, two test tubes, conductivity wires, 9 V battery, current indicator (LED), water, sodium iodide or sodium sulphate, glass or plastic rod **Materials for the reduction of metal ions and halogens:** Test tube stand with test tubes, glass rod, thermometer, spatula and glass rod Metal powders: Mg, Zn, Cu, Fe Salt solutions: $CuSO_4$(aq), $ZnSO_4$(aq), $MgSO_4$(aq), $NaC\ell$(aq) Halide solutions: $KC\ell$ (aq), KBr(aq), KI(aq), chlorine water (or household bleach), bromine water Non-polar solvent: Tetrachloromethane ($CC\ell_4$)						
	Homework: Complete the report on the practical investigation and answer the questions	134	326–328		D89–D91	451 Ex. 13.3 1–2	244–245
2	• Define the galvanic cell in terms of: – self-sustaining electrode reactions – conversion of chemical energy to electrical energy • Define anode and cathode in terms of oxidation and reduction • Define the electrolytic cell in terms of: – electrode reactions that are sustained by a supply of electrical energy – conversion of electrical energy into chemical energy **Understanding the processes and redox reactions taking place in cells** • Describe: – the movement ions through the solutions – the electron flow in the external circuit of the cell – the half-reactions at the electrodes – the function of the salt bridge in galvanic cells • Use cell notation or diagrams to represent a galvanic cell	134	329–331			452–455 462–465	
	Homework: Make summary notes on how an electrochemical cell works; *ES Ex. 13.4 Q. 2	134	329–331 *ES 461		*ES 246–248	461 Ex. 13.4 Q. 2	246–248
3	**Relationship of current and potential to rate and equilibrium** • Give and explain the relationship between current in an electrochemical cell and the rate of the reaction • State that the potential difference of the cell (V_{cell}) is related to the extent to which the spontaneous cell reaction has reached equilibrium • State and use the qualitative relationship between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction: *V_{cell} decreases as the concentration of product ions increases and the concentration of reactant ions decreases until equilibrium is reached at which V_{cell} = 0V (the cell is 'flat')* • (Qualitative treatment only; Nernst equation is NOT required)	136	328–329	*ES Ex. 13.5 Q. 1–3	*ES 248–250	462–465	248–250
	Homework: Include the relationship of current and potential to rate and equilibrium in your summary notes	136	328–329			464 Ex. 13.5 1–3	248–250

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science* LB	*Everything Science* TG
4	**Standard electrode potentials** • Give the standard conditions under which standard electrode potentials are determined • Describe the standard hydrogen electrode and explain its role as the reference electrode • Explain how standard electrode potentials can be determined using the reference electrode • State the convention regarding positive and negative values	136	332–336 355–356		SA Q. 5, 9	456–461	
Homework: Make notes to summarise standard electrode potentials; *ES Ex. 13.4 Q. 1, 3, 4		136	332–336 *ES 461–462		*ES 246–248	461–462 Ex. 13.4 1, 3, 4	246–248

	STUDY AND MASTER PHYSICAL SCIENCES **Week 6: Electrochemical reactions**						
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science*** **LB**	***Everything Science*** **TG**
1	Use the Table of Standard Reduction Potentials to calculate the emf of a standard galvanic cell Use a positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions	136 134	336–339 341–342	TY 9 Q. 2, 4	D91–D92	467–471	250–251
Homework: *ES Ex. 13.6 Q. 1–4			*ES 471–472		*ES 250–251	471–472 Ex. 13.6 Q. 1–4	250–251
2	**Writing equations representing oxidation and reduction half-reactions and redox reactions** • Predict the half-cell in which oxidation will take place when connected to another half-cell • Predict the half-cell in which reduction will take place when connected to another half-cell • Write equations for reactions taking place at the anode and cathode • Deduce the overall cell reaction by combining two half-reactions	136	339	ES Ex. 13.7 Q. 1–3	ES 251–252	466 472–475	251
Homework: TY9 Q. 3, 5, 6		136	342–343		D91–D92	476 Ex. 13.7 Q. 1–3	251–252
3	• Describe, using half-equations and the equation for the overall cell reaction, the following electrolytic processes: – the decomposition of copper chloride – a simple example of electroplating (e.g. the refining of copper)	137	340–341	ES Ex. 13.9 Q. 1–4	ES 253–256	476–480	252–253
Homework: TY 9 Q. 1, 7–9; TY 10 Q. 2		137	341 349		D91–D93	480 Ex. 13.9 1–4	253–256
4	**Oxidation numbers and application of oxidation numbers** • Revise from Grade 11 and extend in Grade 12	137	343–344	SA Q. 6–8, 10	D96–D97	481–482 487–489	259–260
Homework: *ES Ex. 13.11 Q. 1–3			349 ES 489		*ES 259–260	489 Ex. 13.11 1–3	259–260

STUDY AND MASTER PHYSICAL SCIENCES Week 7: Electrochemical reactions, the chemical industry							
S #	**CAPS concepts, practical activities and assessment tasks**	**CAPS pp.**	**LB pp.**	**LB act.**	**TG pp.**	***Everything Science***	
						LB	**TG**
1	• Describe the electrolytic process used industrially in the production of chlorine (the chemical reactions of the chloroalkali industry): – half-equations and the equation for the overall cell reaction – the layout of the particular cell using a schematic diagram – potential risks to the environment	137	344–346 353	Act. 15	D94–D95	487–488 490–491	260–263
Homework: SA Q. 10, 11; *ES Ex. 13.11 Q. 4–8		137	356–357 *ES 490–491		D97 *ES 260–263	490–491 Ex. 13.11 Q. 4–8	260–263
2	• Describe the electrolytic process used industrially in the recovery of aluminium metal from bauxite (South Africa uses bauxite from Australia): • half-equations and the equation for the overall cell reaction • the layout of the particular cell using a schematic diagram • potential risks to the environment	137	347–348 350–351	Act. 14	D94	482–486	256–259
Homework: TY 10 Q. 1; *ES Ex. 13.10 Q. 1–4		137	349 *ES 486–487		D91 *ES 256–259	486–487 Ex. 13.10 1–4	256–259
3	**The fertiliser industry (N, P, K)** • List, for plants: – three non-mineral nutrients, i.e. nutrients that are not obtained from the soil: C, H and O and their sources, i.e. the atmosphere (CO_2) and rain (H_2O) – three primary nutrients: N, P and K and their source, i.e. the soil • These nutrients are mineral nutrients that dissolve in water in the soil and are absorbed by the roots of plants • Fertilisers are needed because there are not always enough of these nutrients in the soil for healthy growth of plants • Explain the function of N, P and K in plants • Give the sources of N (guano), P (bone meal) and K (German mines) before and after the First World War • Interpret the N:P:K fertiliser ratio • Describe and explain (rates, yields, neutralisation, …), using chemical equations wherever appropriate, the following aspects of the industrial manufacture of fertilisers, given diagrams, flow charts and so on for: – N_2 – fractional distillation of air – H_2 – at SASOL from coal and steam – NH_3 – Haber Process – HNO_3 – the Ostwald Process	138–139	359–367	TY 1 Q. 1–4	D99	494–500	266–268
Homework: TY 2 Q. 1–4; *ES Ex. 14.1 Q. 1–5		139–140	367 *ES 499–500		D99 *ES 268–269	499–500 Ex. 14.1 Q. 1–5	268–269

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	**TG**
4	• Describe and explain (rates, yields, neutralisation, …), using chemical equations wherever appropriate, the following aspects of the industrial manufacture of fertilisers, given diagrams, flow charts and so on for: – H_2SO_4 – including the Contact Process – H_3PO_4 and $Ca(H_2PO_4)_2$ (superphosphates) – NH_4NO_3 (ammonium nitrate), $(NH_4)_2SO_4$ (ammonium sulfate) and H_2NCONH_2 (urea) • Give sources of potash (mined imported potassium salts like KNO_3, K_2SO_4) • Link SASOL to the production of fertilisers, e.g. ammonium nitrate (fertiliser and explosive)	139–140	368–371	TY 3 Q. 1–3	D100	270–279	
Homework: Learn the work covered so far in 'The chemical industry' unit; TY 4 Q. 1–3		139–140			D100–D101	271–279	

STUDY AND MASTER PHYSICAL SCIENCES Week 8: Chemical industry

S #	CAPS concepts, practical activities and assessment tasks	CAPS pp.	LB pp.	LB act.	TG pp.	*Everything Science*	
						LB	**TG**
1	• Give sources of potash (mined imported potassium salts like KNO_3, K_2SO_4) • Link SASOL to the production of fertilisers, i.e. ammonium nitrate (fertiliser and explosive) **Homework:** Resource 6: Worksheet 4: Chemical industries (fertilisers)	139–140	372–376	WS 4	WS 4 memo	500–505	280–281
Homework: SA Chemical change: Q. 1–7			377–378		D102–103	506–512	
2	• Give sources of potash (mined imported potassium salts like KNO_3, K_2SO_4) • Link SASOL to the production of fertilisers, i.e. ammonium nitrate (fertiliser and explosive)	139–140	379–380	SA Q. 8–12		506–512	282–284
3	**Revision**						
4	**Revision**						

STUDY AND MASTER PHYSICAL SCIENCES Weeks 9–11: Preliminary examinations

2. Assessment term plan

2.1 Term 3: Possible formal and informal assessment tasks included in each set of LTSMs

Name of book	Experiments **Note: * is the prescribed Term 3 experiment for formal assessment in 2020**	Examinations
Solutions for All Physical Sciences	***Week 1:** Physics Emf of a cell Effective resistance of a series and parallel circuit Short circuits and open circuits LB pp. 339–340, 345–346 TG pp. 242–244, 248-249 **Week 3:** Physics The photoelectric effect LB pp. 402–403 TG pp. 329–330 **Week 4:** Chemistry Investigate the reduction of metal ions and halogens LB pp. 434–438 TG pp. 351–353 **Week 5:** Chemistry Investigate electrolysis of water and sodium iodide LB pp. 449–451 TG pp. 361–363 **Week 6:** Chemistry Find the galvanic cell with the highest potential LB pp. 453–454 TG pp. 363–365	**Weeks 9–11:** Prelim examinations provided by the KZN Department of Education
Study and Master Physical Sciences	***Week 1:** Physics Emf of a cell Effective resistance of a series and parallel circuit Short circuits and open circuits LB pp. 267–271 TG pp. D71–D75 **Week 3:** The photoelectric effect LB pp. 306–307 TG p. D84 **Week 4:** Find the galvanic cell with the highest potential LB pp. 325–326 TG p. D89 **Week 5:** Investigate electrolysis of water and sodium iodide Investigate the reduction of metal ions and halogens LB pp. 326–328 TG pp. D89–D91	**Weeks 9–11:** Prelim examinations provided by the KZN Department of Education

3. Guidelines for lesson planning and preparation

The planners provide details of the content that you need to teach to your class. However, to deliver the lessons successfully, you must do the necessary preparation yourself. This entails thinking about a number of key aspects, including those noted below.

3.1 Check the term focus

You should note the focus for the term. The CAPS document provides clear details regarding the focus of each term. For Grade 12, the focus for Term 3 is set out below:

Term 3:

Physics: Electric circuits
Electrodynamics
Optical phenomena

Chemistry: Electrochemical reactions
The chemical industry

Term 4: Revision

See Resource 4 for an overview of the topics for Term 3.

3.2 Prepare resources

This stage in your preparation is vital. The prescribed Learner's Books provide both information and activities. The Teacher's Guides also provide valuable information as teaching guidelines. When you are planning, you need to be familiar with the information in the textbook your learners will be using. This will ensure that you do not need to either read from the textbook or ask your learners to copy down notes from the chalkboard or projector.

Teaching Physical Sciences should not be based on reading and discussing the textbook. Learners need activities, demonstrations, problem solving opportunities and active debates. This all takes careful planning and preparation of resources.

Resources can range from everyday objects such as a battery powered toy car moving up an inclined plane, to more scientific apparatus like burettes, volumetric flasks and universal pH strips, or even digital resources like a short video clip or simulation. Whatever resource you select as the focus of the lesson, make sure you think carefully about the questions you will ask learners to think about and discuss. You may plan these discussions in pairs or small groups. Through observation, reflection and discussion you will engage learners in helping them construct their own knowledge. It is important to challenge this knowledge and at times disagree with them even if they are correct. You can also present a common misconception and encourage them to be critical of the proposed idea.

Problem solving and application of knowledge are very important in Physical Sciences. Your learners will need to practise exam-type questions; the textbooks all give worked examples. There are also end-of-chapter or unit questions, exam practice and additional worksheets. These have been referenced in the planner for each book and are included as homework activities. However, in some cases the Learner's Book may not have enough questions and we have referred you to additional activities from the ***Everything Science*** textbook. If your learners don't have a copy, they can access these questions online from www.everythingscience.co.za. The Learner's Books can also be downloaded or print copies can be ordered from a supplier referred to on the same site. There is a huge database of questions that will be very useful for learners to work through both for remediation, revision and extension. Not all the activities are referenced in the planner. If you identify that your learners are struggling in a particular section, select questions that are relevant to them.

A list of resources for the term appears on the following page, in case you want to collect these well in advance. Otherwise resources are listed per week. You will find it worthwhile to collect these well in advance and leave them in a box or something similar. This way, you will avoid a last-minute rush. Remember that some materials are used on several different occasions, so keep laboratory equipment safe and well cleaned. Depending on how quickly your learners complete a section, and on what activities you choose, you may find that you are still on a certain week when the following week's requirements are listed. Continue normally and check with the CAPS document to find out what you still need.

Solutions for All	
Week	**Resources**
1	1,5 V battery (cell), resistor, ammeter, voltmeter, switch, connecting leads Length of low-resistance wire Copies of Resource 7: "Further questions to answer after completing the investigation on electric currents".
2	https://www.youtube.com/watch?v=gQyamjPrw-U https://www.youtube.com/watch?v=gQyamjPrw-U http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/laplace_lorentz_force_electric_motor_principle_brushes_split_ring.htm Optional: Materials to build a generator and/or motor: Enamel-coated copper wire, 4 large ceramic block magnets, cardboard (packaging), large nail, 1.5 V 25 mA light bulb, 9 V cell
3	Gold leaf electroscope, zinc plate, UV lamp (see Resource 5 in this planner) Mercury discharge lamp, photosensitive vacuum tube, set of light filters, circuit to produce retarding voltage across phototube, oscilloscope, ammeter Copies of Resource 6: Worksheet 1 (as homework) https://phet.colorado.edu/sims/photoelectric/photoelectric_en.jnlp
4	Zinc, lead, aluminium and copper electrodes, zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide, potassium nitrate, four beakers, sandpaper Three test tube racks; 9 large test tubes; solutions of chlorine water, bromine water and iodine water; 0,2 $mol \cdot dm^{-3}$ solutions of halides $NaC\ell$, NaBr and NaI; non-polar solvent such as xylene or dichloromethane; three droppers; glass stirring rod
5	Water bowl, electrodes for the electrolysis of water, test tubes, conductivity wires, 9 V battery, current indicator (LED), water and sodium iodide and sodium sulphate
6	Zinc; lead; aluminium and copper electrodes; solutions of zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide and potassium nitrate; 2 beakers; U-tube; cotton wool; voltmeter; connecting leads
7	Resource 6: Worksheet 4: Chemical industries (fertilisers)

Study and Master	
Week	**Resources**
1	1,5 V battery, 3 resistors of different values, ammeter, voltmeter, switch, 7 connecting leads 1,5 V battery, 3 resistors of different values, ammeter, voltmeter, switch, minimum of 7 connecting leads **Demonstration:** Battery, connecting wires, several resistors of different values, several voltmeters, several ammeters, switches, a length of low resistance wire Copies of Resource 7: "Further questions to answer after completing the investigation on electric currents".
2	https://www.youtube.com/watch?v=gQyamjPrw-U https://www.youtube.com/watch?v=gQyamjPrw-U http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/laplace_lorentz_force_electric_motor_principle_brushes_split_ring.htm Enamel-coated copper wire, 4 large ceramic block magnets, cardboard (packaging), large nail, 1.5 V 25 mA light bulb, 9 V cell
3	Gold leaf electroscope, zinc plate, UV lamp (see Resource 5 in this planner) Mercury discharge lamp, photosensitive vacuum tube, set of light filters, circuit to produce retarding voltage across phototube, oscilloscope, ammeter Copies of Resource 6: Worksheet 1 (as homework) https://phet.colorado.edu/sims/photoelectric/photoelectric_en.jnlp
4	Zinc, lead, aluminium and copper electrodes; solutions of zinc sulphate, copper sulphate, lead nitrate, sodium hydroxide and potassium nitrate; 2 beakers; U-tube; cotton wool; voltmeter; connecting leads
5	Materials for the electrolysis of water: Water bowl, two electrodes for the electrolysis of water, two test tubes, conductivity wires, 9 V battery, current indicator (LED), water, sodium iodide or sodium sulphate, glass or plastic rod Materials for the reduction of metal ions and halogens: Test tube stand with test tubes, glass rod, thermometer, spatula and glass rod; Metal powders: Mg, Zn, Cu, Fe Salt solutions: $CuSO_4(aq)$, $ZnSO_4(aq)$, $MgSO_4(aq)$, $NaC\ell(aq)$ Halide solutions: $KC\ell$ (aq), KBr(aq), KI(aq), chlorine water (or household bleach), bromine water; Non-polar solvent: Tetrachloromethane ($CC\ell_4$)
7	Copies of Resource 6: Worksheet 4: Chemical industries (fertilisers)

3.3 *Check your own knowledge of the content*

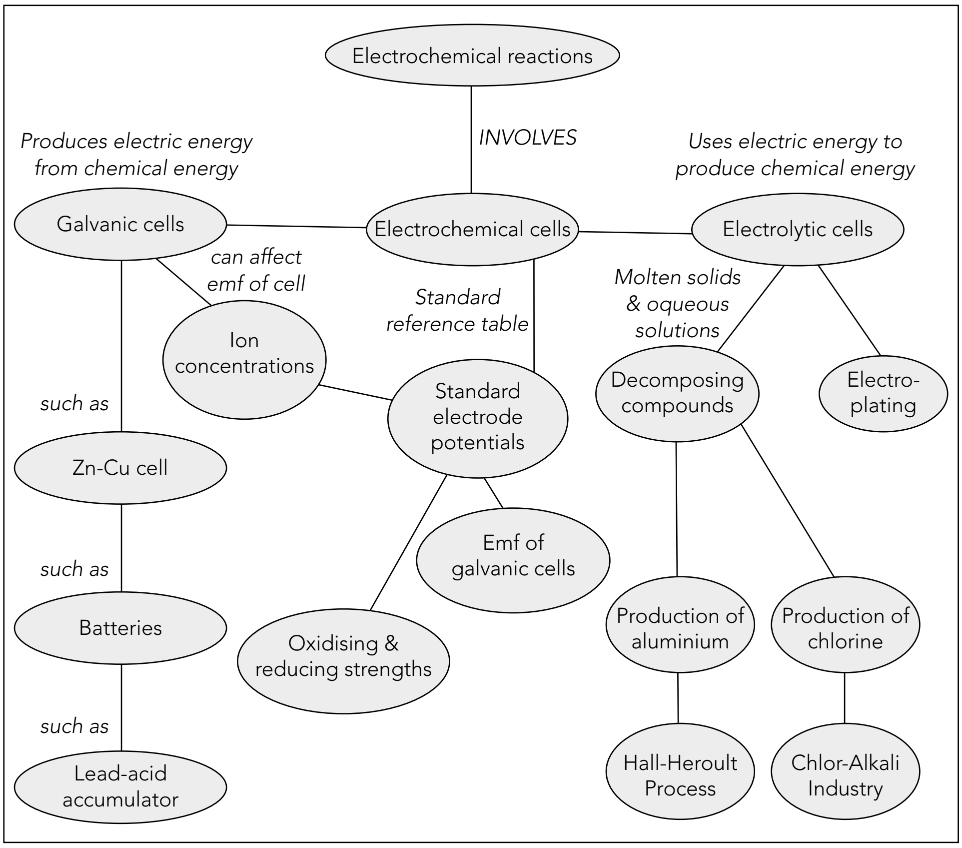
However well you know your work, it is easy to make small mistakes when in a classroom with learners asking questions. It is a good idea for you to read through the content to be covered and to ensure that you are very familiar with the work. Also do additional reading from other sources if possible. You should refer to Resource 4 for an overview of the Term 3 topics and to Resource 5, *Additional Information and Enrichment Activities*, where there is additional information about many of the topics for the term and where some common errors, not always made explicit in the Learner's Books or Teacher's Guides, are addressed.

3.4 *Prepare the conceptual framework for the lesson topic*

Before each lesson, the teacher needs to prepare the content to be taught. This involves many aspects, such as thinking carefully about how the concepts are organised in a conceptual framework; how to help learners develop this framework for themselves; what possible questions learners might ask; or difficulties they might have and how to address these.

A useful way for teachers to prepare the content is to summarise the topic in their own minds using a tool like a mind map or a concept map. A concept map is different from a mind map because we describe the links between the concepts to show the relationship between them. Below is an example of a concept map for the topic electrochemical reactions.

EXAMPLE 1: CONCEPT MAP OF ELECTROCHEMICAL REACTIONS



When you introduce a topic learners will benefit from seeing the big picture and a concept map is a useful way to present this. It is also a useful way of showing learners how the class is progressing. At the end of the topic encourage your learners to make their own summaries in words and/or pictures. In this way, they will interact with concepts, and this in turn will promote deep learning.

While you prepare the conceptual framework, it is important to think about what prior knowledge learners should have and to have a clear idea of where and when they will need to draw on the concepts taught in the previous years. It is vital that you are familiar with the Grade 12 Examination Guides for Physical Sciences and the topics taught in Grades 10 and 11.

In your preparation, think carefully about the types of questions learners will ask. You may want to preempt some of these questions by asking open-ended questions to arouse learners' curiosity and to engage them in the process of learning. It is also a good idea to leave a question unanswered for a short time and let the lesson activities suggest a possible answer. If the question is still unanswered, then you should provide the necessary help. Doing this will provide good opportunities for you to correct any wrong ideas or misconceptions.

3.5 Baseline assessment and remediation of misconceptions

Baseline assessment should take place at the beginning of each new topic to establish what learners already know and to pick up any possible misconceptions. Some of the most common of these misconceptions for Term 3 have been addressed in relation to the relevant CAPS content in Resource 5, *Additional Information and Enrichment Activities*, of this document. Baseline assessment can take many forms – such as a quick question and answer session or a paper and pencil activity. Once a gap in understanding or a misconception has been identified (e.g. some people think that when you kick a ball, it continues to move forward because of the force of the kick) you need to find a way to help prepare learners for the new work which is going to be taught in the term. In this context the word **remediation** refers to overcoming the learners' wrong ideas.

3.6 Learner activities

Give some thought to what learners will actually do in each lesson. Teaching Physical Sciences should not be based on reading and discussing the textbook. Some examples of activities they can do in each lesson include: Answering questions by writing the answers (the CAPS encourages writing); completing translation activities by converting a drawing to a description, or a table to a graph. You set the stage for the learner activities by giving explanations about different concepts, asking questions, setting problem-solving activities, or giving clear instructions about what learners need to do.

Think carefully about the questions you will ask learners to think about and discuss. You may plan these discussions in pairs or small groups. Through observation, reflection and discussion you will engage learners, helping them construct their own knowledge. It is important to challenge this knowledge and at times disagree with them, even if they are correct. You can also present a common misconception and encourage them to be critical of the proposed idea.

Problem solving and application of knowledge are very important in Physical Sciences. Your learners will need to practise exam-type questions; the learner's books all give worked examples. There are also end-of-chapter or unit questions, exam practice and additional worksheets. These have been referenced in the planner for each book and are included as homework activities. However, in some cases the learner's book may not have enough questions and we have referred you to additional activities from the Everything Science books. There is a huge database of questions that will be very useful for learners to work through both for remediation, revision and extension. Not all the activities are referenced in the planner. If you identify that your learners are struggling in a particular section, select questions that are relevant to them.

In Resource 5, *Additional Information and Enrichment Activities*, of this document you will find ideas for activities for Term 1 and Term 3 linked to several of the CAPS topics beyond those given in many of the LTSMs. You should refer to this resource when preparing your lessons. In some cases, a more appropriate practical activity than the one in the Learner's Book is described and you can use it instead.

Always allow time in your lessons to review learners' work and to give formative feedback on any assessment that has been done. Make sure when going over written work which you do not take in yourself, that you have a list of possible answers.

3.7 Informal assessment

In addition to specifying the number and nature of the formal assessment tasks, the CAPS suggests that there should also be on-going informal assessment each term. Learners can do a variety of informal assessment tasks, both in class and for homework, and many of the Learner's Book activities are useful for this purpose. Informal assessment tasks do not have to be marked by the teacher. You can allow learners to mark their own or each other's work. You should consider taking in about five or six pieces of work from time to time to help you assess progress informally and also to keep learners attentive. Give learners a surprise by changing your review techniques from time to time.

While learners do not always need marks for their work, they do need feedback, and you need to know what they managed or did not manage in the task in order to correct and support their learning. You may like to record any marks that are awarded or key comments for your own interest.

3.8 Learners with special needs

As we know, people are not all the same. Learners will attend the Physical Science classes with different needs, styles of learning and also with a variety of alternative ideas about scientific phenomena. It is challenging for a teacher to accommodate all these different features. However, you are encouraged to consider these differences in your preparation. You should also consult resources provided by the DBE. The textbooks also provide additional suggestions.

For different learning styles, the teacher can use a variety of teaching methods. These include whole class teaching, peer interaction, small-group learning, writing activities, drawing and mind-mapping activities, presentations, debates and role play. Wherever possible, encourage reading, writing and speaking skills.

3.9 Enrichment

In certain tasks, learners will work at different speeds. For those learners who complete their work earlier than others refer to enrichment or extension activities in the Teacher's Guide, those suggested in Resource 5, *Additional Information and Enrichment Activities*, or the worksheets in Resource 6, all in Section C of this planner.

3.10 Homework

It is essential for Grade 12 learners to do homework every day. It is wise to examine the planner and decide what sorts of tasks are appropriate for homework each week. Allow a few minutes at the end of the each lesson to provide homework instructions. Homework can be a useful consolidation exercise and need not take learners very long. If well planned in advance, learners can sometimes be given a longer homework exercise to be handed in within a week. This arrangement allows for flexibility. It is absolutely essential to allow a few minutes at the start of lessons to review the previous day's homework.

3.11 Practical work

Practical work must be integrated with theory to strengthen the concepts being taught. It may take the form of a simple practical demonstration or an experiment or practical investigation. Some of these practical activities will be done as part of formal assessment and others can be done as part of informal assessment. Learners need to understand and experience that practical work in science distinguishes this discipline from other knowledge areas.

For learners to achieve the most from their experience of practical work, you need to be extremely well prepared. Think carefully and plan how to accommodate all learners in doing practical activities. In most schools, there may be a limited amount of equipment. This means that you may need to give groups of learners the opportunity to complete the practical work after school hours. If equipment is limited, one solution is to set up different stations with different equipment. Learners rotate from one station to the next in order to complete a series of experiments. Learners also need to be well prepared for any formal or informal practical work. In the planners, you will see that learners are required to review the investigations for homework on the day before they are required to do the investigation. You could ask them to complete pre-practical questions.

Safety is critical whenever doing practical work. Please ensure you regularly discuss safety rules with your learners. Refer to the websites below that deal with laboratory safety:

- International chemical safety cards: www.inchem.org/pages/icsc.html
- Merck safety data sheets: www.merck-chemicals.com/msds-search/
- School chemistry laboratory safety guide: www.cdc.gov/niosh/docs/2007-107/ pdfs/2007-107.pdf
- WCED laboratory safety guidelines: www.curriculum.wcape.school.za/site/52/ pol/view/

To conduct a successful practical activity, the following procedures are suggested:

- Before the practical session, check that the materials are the correct ones so that no mistakes occur.
- Talk through the activity with learners or read the descriptions from the learner's book with them.
- Stop from time to time to emphasise certain points. For example, **'Remember to use safety glasses and not to look directly at burning magnesium.'**
- Let learners sometimes work in their chosen groups of friends and change the groups on other occasions.
- Keep a watchful eye on the activity and walk around looking at what learners are doing. This teaching strategy provides the teacher with an opportunity to assess their skills of working with apparatus.
- Drawing the experimental set-up on the chalkboard or another medium helps learners to focus.
- Ensure that books and bags are safely stowed away from the practical work area.
- Enforce a strict rule of **no tasting**. There should be no eating of any kind at all in the laboratory or classroom where investigations are conducted.
- Ensure that work areas are clean both before and after the practical activity.
- Encourage learners to wear plastic aprons and safety glasses and insist on closed shoes wherever possible.
- Insist on the correct labelling of all tubes and bottles.
- Set a good example by following correct procedures at all times.
- Insist that learners tidy their work places when they have finished.
- Have a supply of tap water at hand in case of accidental acid spills. Do not attempt to neutralise acids and bases on a learner or yourself. Simply wash with plenty of water.
- Have a fire extinguisher handy and know how to use it.
- Keep a supply of gauze and plasters in a simple first aid box. A plastic container works well.

3.12 Reflect on the lesson

At the end of each lesson you should reflect on how the lesson went and jot down your thoughts. The template provided in this book has prompts to assist you in this. Your reflection will help you identify ways in which you could better support your learners or where you need help in doing so. Notes you make will be useful when you prepare to teach the same lesson another time.

4. Overview of the Term 3 topics

The preliminary examinations usually take up 3 weeks of the time allocated to teaching and learning, so it is essential to keep up to date with the CAPS schedule of work for Grade 12 during this term.

Electric circuits

In Grade 11, learners solved problems of series, parallel, and combinations of series and parallel circuits using Ohm's Law, the formulae for calculating effective resistance of combinations of resistors, and for calculating energy transferred and power in circuits. In Term 3, this topic builds on this knowledge and understanding by introducing the electromotive force (emf) of the battery and its internal resistance.

The first experiment in Term 3 measures the internal resistance of a cell, and determines the effective resistance of a series and parallel combination of resistors. This experimental work gives learners the opportunity to test theory with a practical investigation. Both of the textbooks have detailed and clear instructions on how these investigations can be carried out. A post-investigation worksheet is provided in Resource 7. This worksheet can be used to test the learners' understanding of the practical work and to find out whether they are able to apply knowledge to solve problems. A memorandum is supplied.

The internal resistance can be treated just like another resistor in the circuit. The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf.

$$\varepsilon = V_{\text{load}} + V_{\text{internal resistance}}$$

V_{load} is also referred to as the terminal potential difference V_{terminal} in some textbooks and examination questions.

$V_{\text{internal resistance}}$ is sometimes referred to as the 'lost volts' since the energy per unit charge in transferring charge through the battery (cell) is 'lost' for use in the external circuit. The voltage is, however, not 'lost'.

Electrodynamics

Faraday's Law of electromagnetic induction governs the generation of electricity when a coil is linked to **changing** magnetic flux. This is how generators work.

The **motor effect** governs the rotation of a current-carrying coil when it is placed within a magnetic field.

Although both a motor and a generator consist of a coil placed in a magnetic field, they operate on these two distinct principles. It is useful to remind learners that a motor requires electricity in order to work – e.g. you have to plug a fan into the power supply to turn it on to move the air. A generator generates electricity – it therefore does not have a power supply attached to it – it provides electricity at its terminals.

Optical phenomena and properties of matter

The photoelectric effect gives definitive evidence of the quantisation of electrons in energy levels. The mystery of why and how it occurs fascinated Einstein, because it cannot be explained by the classical model of light as a wave. Einstein came up with the startling idea that light is both a wave and a particle. When explaining the details of this effect, it is important to emphasise how Einstein's explanation of it changed scientists' thinking from 1905 onwards.

Resource 5 contains some ideas on how to teach the photoelectric effect. These ideas come from the British Institute of Physics TAP (Teaching Advanced Physics) series which is available on the internet.

The University of Colorado produces the PHET simulations that cover many topics in Physics, Chemistry and Biology. The beauty of these simulations is that they are designed to give similar results to 'real-life' experiments, and they are authored and checked by university professors before they are released to the public.

The PHET simulation for the photoelectric effect is an excellent teaching tool. You can use it in many different ways to demonstrate the photoelectric effect experiment. There are also quite a few YouTube videos of teachers explaining the effect while making use of the PHET simulation. One of the better clips, found at https://www.youtube.com/watch?v=ubkNGwu_66s, demonstrates the basics of the effect.

Another very useful article is https://allinonehighschool.files.wordpress.com/2013/06/day-168-photoelectric-lab.pdf. The author shows how learners can use the simulation to work their own way through the theory. This site also provides a worksheet for the learners, as well as a memorandum.

Another topic that is difficult to explain or demonstrate is line emission and absorption spectra, as many schools do not have the necessary apparatus. The origin of spectral lines is well presented and explained in https://youtu.be/1uPyq63aRvg. The TAP series also has a very useful set of teaching tips for this topic. These can be found in Resource 5 in Section C of this planner.

Electrochemical reactions

Redox reactions were introduced to the learners in Grade 11. They need to be reminded about oxidation, reduction, oxidising and reducing agents and oxidation numbers when you start teaching this topic in Grade 12.

It is important that single arrows are used in redox chemical equations and half reactions because the equations show that the reaction will effectively be proceeding in that direction, even though we know that all chemical (equilibrium) reactions are by nature able to be reversed.

The electrochemical (galvanic) cell transfers chemical energy to electrical energy, and the process of electrolysis transfers electrical energy to chemical energy. These two cells work in the 'opposite' way. Learners tend to confuse the processes by which they work, and hence they struggle to write appropriate half reactions and/or to identify the cathode and anode correctly.

The chemical industry

The chemical industries topic involves considerable amounts of rote learning, as well as integration of prior knowledge of chemical equilibrium, stoichiometry and redox reactions. The CAPS syllabus stipulates 6 hours of teaching time for this topic; however, it will have to be condensed into 4 hours in order to complete the syllabus before the preliminary examinations. While teaching this you can revise many of the other sections too.

Resource 6 of this document provides an extract from the Chemical Industries Resource Pack which may help learners to work through the content. The complete resource pack is found at http://open.uct.ac.za/handle/11427/7445. This site also has animations of the processes and will enhance your learners' understanding.

5. Additional information and enrichment activities for Term 3

Term 3

Activities are listed in italics. The list is not exhaustive and more information can be found in the CAPS document.

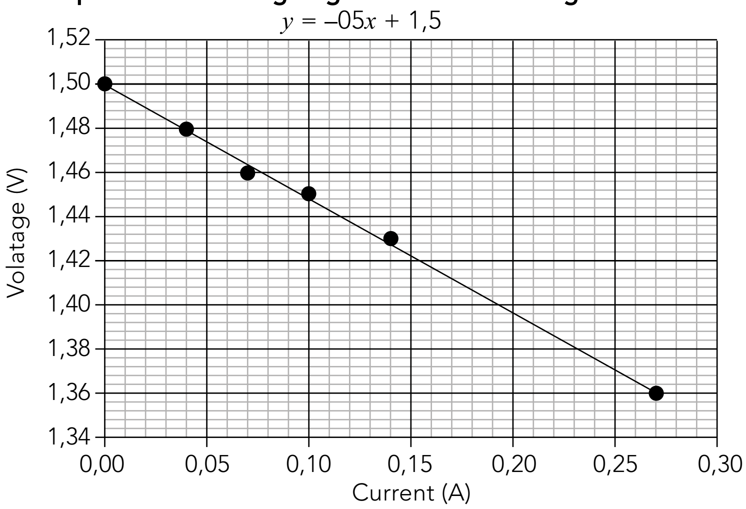
CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
Week 1: Electric circuits	

Electric circuits

An alternative method of determining the internal resistance of a cell (battery) is to take various readings of the load voltage and current through the circuit, using resistors of different values. A set of results of such an experiment are shown below.

Load voltage (V)	Current (A)	Load voltage (V)	Current (A)
1,36	0,27	1,46	0,07
1,43	0,14	1,48	0,04
1,45	0,10	1,50	0

Graph of load Voltage agains Current through the cell



The graph is linear with a negative slope.

$\varepsilon = V_{load} + V_{internal\ resistance}$

$\varepsilon = IR + Ir$ where R = external circuit resistance, r = internal resistance

The graph was plotted as V_{load} against I, therefore we change the subject of the formula for this equation to V_{load}

$V_{load} = \varepsilon - V_{internal\ resistance}$

$V_{load} = -Ir + \varepsilon$

Thus the equation of the graph $y = mx + c$ (which in this case is $y = -0{,}5x + 1{,}5$) gives us the emf of the cell (1,5) and its internal resistance (0,5 Ω).

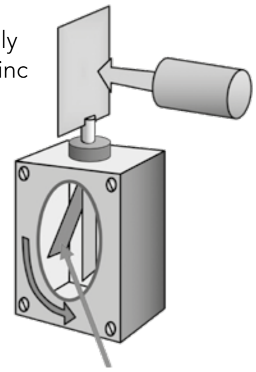
NB: There have been some questions based on these kinds of results in past NSC papers. It is worth explaining this reasoning to the learners once they have mastered the basics.

Week 2: Electrodynamics	
Electrodynamics	There are many YouTube videos that can help in explaining how a generator and a motor work. There are also simulations showing the principles of Faraday's Law. Animations and videos are often more helpful in explaining how things work than reading the text in a book.

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
The generator	The generator works on the principle of electromagnetic induction. Faraday's Law describes the relationship between the rate of change of magnetic flux and the magnitude of the induced emf. Lenz's Law is used to predict the polarity of the induced emf. Lenz's Law is not examinable in the NSC. Generating electricity: https://www.youtube.com/watch?v=20Vb6hlLQSg The world's simplest generator: https://www.youtube.com/watch?v=n4uQIOSp14o&feature=iv&src_vid=AS74oAmjpxU&annotation_id=annotation_2154302197
Week 3: Electrodynamics	

The DC motor	The electric motor works on the 'motor effect' principle. When a current-carrying conductor is placed in a magnetic field, the conductor experiences a force which is given by $F = BIL \sin \theta$. Learners do not have to learn how to use this formula, but it is useful to remember the following:
	• If the direction of flow of current is parallel to the direction of the magnetic field, the conductor will not experience force because $\sin 0° = 0$
	• When the direction of flow of current is perpendicular to the direction of the magnetic field, the conductor will experience maximum force because $\sin 90° = 1$
	• The force on the conductor increases when:
	  – magnetic field intensity increases
	  – current increases
	  – the length of the conductor within the magnetic field increases
	The following factors are used to design more powerful motors:
	• If the current flows at 90° to the magnetic field, the conductor experiences maximum force – the position of the coil determines the torque (turning force) on it
	• When the current is increased, the motor rotates faster
	• Many turns are wrapped on the coil to increase the torque on the coil
	NB: Faraday's Law does not apply to explanations on how the electric motor works.
	The DC motor: https://www.youtube.com/watch?v=LAtPHANEfQo

Alternating current	Learners sometimes struggle to understand why we use high voltage transmission lines to transmit energy over long distances. We transmit electrical energy with minimum power loss in the power lines by sending the energy at low current and high voltage. The power loss in the lines is given by $P_{rms} = I^2_{rms}R$, where I_{rms} is the current and R is the resistance of the line. The resistance of the power lines is relatively low, and if the current is also low, there will be very little electrical energy transferred to other forms of energy (e.g. thermal energy) as it travels from the power station across the country to various towns and cities. AC is easily transformed from low voltage to higher voltage using a step-up transformer. Similarly, it is easily stepped down when it reaches the town, so that the consumer receives electricity at a lower (safer) voltage. Transformers work on principles of electromagnetic induction, so they require a changing magnetic flux to be linked with the conductor. AC provides changing magnetic flux in the primary coil to induce AC voltage in the secondary coil. It is therefore convenient to work with AC rather than DC electrical systems when supplying energy nationally.

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
Week 4: Optical phenomena and properties of materials	
The photoelectric effect	**Demonstration:** **The basic phenomenon** Introduce the topic by demonstrating the electroscope and zinc plate experiment.  Gold leaf falls immediately, the zinc plate is illuminated with ultraviolet light (Diagram resourcefulphysics.org) Point out to learners that the photoelectric effect is apparently instantaneous. However, the light must be energetic enough – for zinc this is in the ultraviolet region of the spectrum. If light were waves, we would expect the free electrons to steadily absorb energy until they escape from the surface. This would be the case in the classical theory, in which light is considered as waves. But in reality, we could wait all day and still red light would not liberate electrons from the zinc plate. So what is going on? We picture the light as quanta of radiation (photons). A single electron captures the energy of a single photon. The emission of an electron is instantaneous as long as the energy of each incoming quantum is big enough. If an individual photon has insufficient energy, the electron will not be able to escape from the metal. **Discussion:** **Summarising the phenomenon** Summarise the important points about the photoelectric effect: • There is a threshold frequency (i.e. energy), below which no electrons are released • The electrons are released at a rate proportional to the intensity of the light (i.e. more photons per second means more electrons released per second) • The energy of the emitted electrons is independent of the intensity of the incident radiation – they have a maximum KE. **Discussion:** **An analogy** Try this analogy, which involves ping-pong balls, a bullet and a coconut on a stand. A small boy tries to dislodge a coconut from the stand on which it is placed by throwing a ping-pong ball at it – no luck, the ping-pong ball has too little energy! He then tries a whole bowl of ping-pong balls but the coconut still stays put! Along comes a physicist with a pistol (and an understanding of the photoelectric effect), who fires one bullet at the coconut – it is instantaneously knocked off its support. Ask how this is an analogy for the zinc plate experiment. (The analogy simulates the effect of infrared and ultraviolet radiation on a metal surface. The ping-pong balls represent low energy infrared, while the bullet takes the place of high-energy ultraviolet.) Now you can define the work function. Use the potential well model to show an electron at the bottom of the well. It has to absorb the energy in one go to escape from the well and be liberated from the surface of the material.

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities

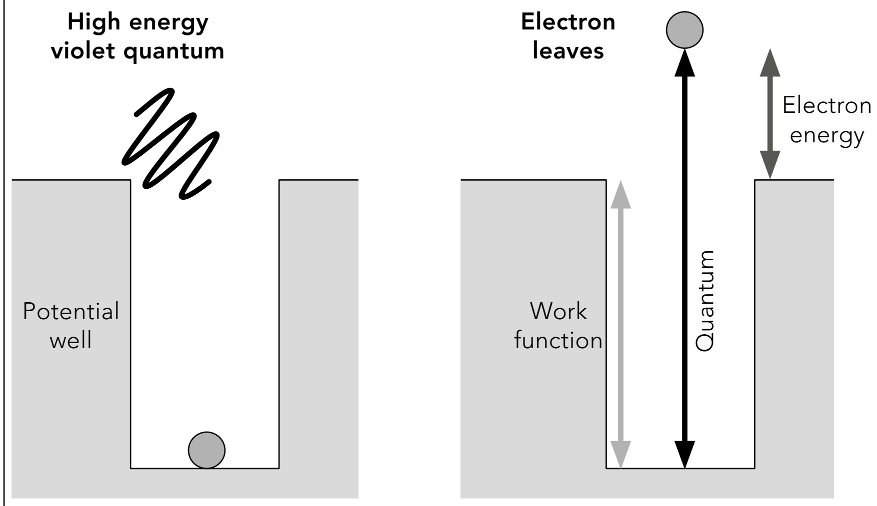
The photoelectric effect (cont.)

Units

The electronvolt is introduced because it is a convenient small unit. You might need to point out that it can be used for any (small) amount of energy, and is not confined to situations involving electrically accelerated electrons.

Potential well

It is useful to compare the electron with a person in the bottom of a well with totally smooth sides. The person can only get out of the well by one jump; they can't jump half-way up and then jump again. In the same way an electron at the bottom of a potential well must be given enough energy to escape in one 'jump'. It is this energy that is the work function for the material.



Now you can present the equation for photoelectric emission:

Energy of photon $E = hf$

Picture a photon being absorbed by one of the electrons which is least tightly bound in the metal. The energy of the photon does two things.

Some of it is needed to overcome the work function $W_o = hf_o$

The rest remains as the kinetic energy of the electron (E_k).

$E = W_o + E_k = hf_o + \frac{1}{2}mv^2$ where m = rest mass of the electron

A voltage can be applied to bind the electrons more tightly to the metal.
The stopping potential V_s is just enough to prevent any from escaping:

$hf = E_o = eV_s$

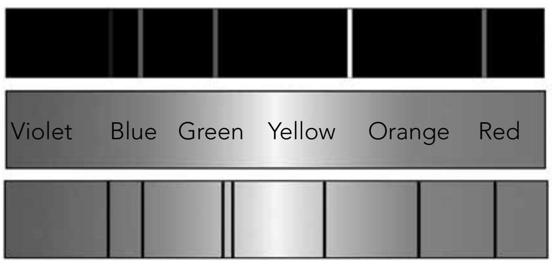
Learners' questions and answers

Worksheet 1 in Resource 6 has questions on the photoelectric effect;
a memorandum with answers is also provided.

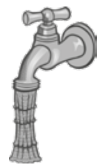
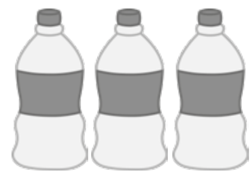
Einstein's ideas

Albert Einstein explained the photoelectric effect in a paper published in 1905. It was the first of four ground-breaking papers he published that year. In the second paper, Einstein explained the mysterious Brownian motion of microscopic particles as due to the random impact of much smaller particles. This work led to the acceptance of the molecular or atomic nature of matter, which until then had been quite speculative. Einstein's third paper that year is now his most famous. Here Einstein introduced his Special Theory of Relativity which, in a fourth paper, led to probably the most famous equation in science, $E = mc^2$, which describes the equivalence of mass and energy.

But it was Einstein's first paper, which contained his work on the photoelectric effect, that at the time was the most revolutionary of the four, and it was for this work that Einstein was eventually awarded the Nobel Prize in 1921. (The Nobel Committee works somewhat more slowly than the speed of light!)

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
The photoelectric effect (cont.)	In this paper Einstein broke away from the idea that light (electromagnetic radiation) is continuous in nature and introduced us to the idea of the quantum (plural quanta) or photon as a 'packet' of light. (The term quantum is used for any packet of energy, while a photon is a quantum associated with electromagnetic radiation.) The wave model of light had been fairly conclusively established a century earlier, mainly due to the work of Thomas Young, who demonstrated and explained interference patterns. But the wave model cannot explain the photoelectric effect; Einstein realised this and took the bold step of putting forward a completely different model in order to explain the following experimental results: • For any given metal, with radiation below a certain threshold frequency, no electrons are released even if the radiation is very intense • Provided the frequency is above the threshold, some electrons are released instantaneously, even if the radiation is very weak • The more intense the radiation, the more electrons are released • The kinetic energy of the individual photoelectrons depends only on the frequency of the radiation and not on its intensity Einstein was the first to use the equation $E = hf$ to explain the photoelectric effect. It is known as the Planck equation, and h is called Planck's constant, because Max Planck had already proposed that when electromagnetic radiation is absorbed or emitted, energy is transferred in packets. This work earned Planck the 1918 Nobel Prize. **External references** The material in this section has been adapted from Salters Horners Advanced Physics, section DIG, activity 30 and from Salters Horners Advanced Physics, section DIG additional sheet 11 (http://saltersinstitute.co.uk/course-the-salters-horners-advanced-physics/)
Week 5: Electrochemical reactions	
Electrochemical reactions	Some useful video clips for this topic can be found at the following web addresses: How the galvanic cell works: https://www.youtube.com/watch?v=J1ljxodF9_g Principles of the Zn-Cu Cell: https://www.youtube.com/watch?v=0oSqPDD2rMA&feature=player_embedded Revision of galvanic and electrolytic cells: https://www.youtube.com/watch?v=Rt7-VrmZuds
Week 6: Optical phenomena and properties of materials	
Line emission and absorption spectra	**Demonstration:** **Looking at emission spectra** Show a white light and a set of standard discharge lamps: sodium, neon, hydrogen and helium. Allow learners to look at the spectrum of each gas. They can do this using a direct vision spectroscope or a bench spectroscope, or simply by holding a diffraction grating up to their eye. What is the difference? (The white light shows a continuous spectrum; the gas discharge lamps show line spectra.) **Emission and absorption spectra**  Emmision spectra Continuous spectrum Absorbsion spectra (Diagram resourcefulphysics.org)

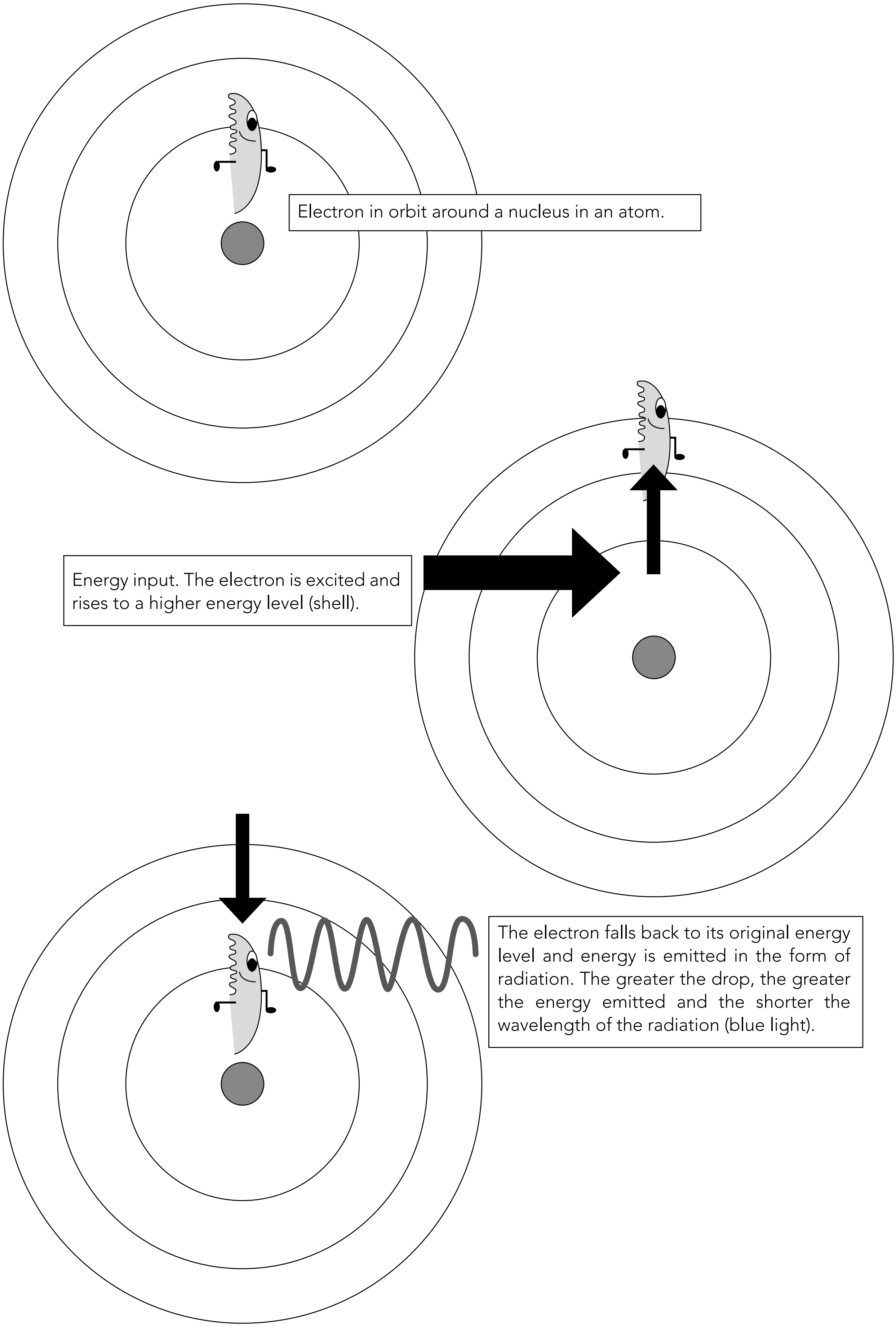
CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
Line emission and absorption spectra (cont.)	The spectrum of a gas gives a kind of 'fingerprint' of an atom. You could relate this to the simple flame tests that learners may have seen in earlier grades. Astronomers examine the light of distant stars and galaxies to discover their composition. Astronomers also use these spectra to tell if a star or galaxy is moving towards the Earth or away from the Earth. If the spectral pattern is the same as a known element but the lines are all shifted to a lower frequency (longer wavelength), we say the light has experienced a red shift. According to the Doppler effect, the source of light (the distant star or galaxy) must be moving away from the Earth. In a similar way, stars and galaxies moving towards the Earth will have a spectral pattern that has been blue-shifted, i.e. the lines appear at a higher frequency (shorter wavelength). Based on many observations of red-shifted stars and galaxies, cosmologists argue that this shows that the Universe is expanding and at some time in the distant past must have started this expansion in a Big Bang. **Discussion:** **The meaning of quantisation** Relate the appearance of the spectra to the energy levels within the atoms of the gas. Learners will already have a picture of the atom with negatively charged electrons in orbit around a central positively charged nucleus. Explain that, in the classical model, an orbiting electron would radiate energy and spiral in towards the nucleus, resulting in the catastrophic collapse of the atom. The classical model must be replaced by the Bohr atomic structure in which orbits are quantised. The electron's energy levels are discrete. An electron can only move directly between such levels, emitting or absorbing individual photons as it does so. The ground state is the condition of lowest energy – most electrons are in this state. Think about a bookcase with adjustable shelves. The bookshelves are quantised – only certain positions are allowed. Different arrangement of the shelves represents different energy level structures for different atoms. The books represent the electrons, added to the lowest shelf first, and so on. **Demonstration:** **Illustrating quantisation** Throw a handful of polystyrene balls round the classroom and see where they settle. The different levels on which they end up – the floor, on a desk, on a shelf – gives a very simple idea of energy levels. The A4 poster from Resourceful Physics > Teachers > OHT > Emission of Light is given at the end of this section. It shows the following: An energy input raises the electrons to higher energy levels. This energy input can be by either electrical, heat, radiation or particle collision. When the electrons fall back to a lower level there is an energy output. This occurs by the emission of a quantum of radiation. **Discussion:** **Energy levels in a hydrogen atom** Show a scale diagram of energy levels. It is most important that this diagram is to scale to emphasise the large energy drops between certain levels. The learners may well ask the question, 'Why do the states have negative energy?' This is because the zero of energy is considered to be that of a free electron 'just outside' the atom. All energy states 'below' this – i.e. within the atom – are therefore negative. Energy must be put into the atom to raise the electron to the 'surface' of the atom and allow it to escape.

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
Line emission and absorption spectra (cont.)	**Worked example and learner questions:** **Calculating frequencies** Calculate the frequency and wavelength of the quantum of radiation (photon) emitted due to a transition between two energy levels. (Use two levels from the diagram for the hydrogen atom.) $E_2 - E_1 = hf$ Point out that this equation links a particle property (energy) with a wave property (frequency). Ask your learners to calculate the photon energy and frequency for one or two other transitions. Can they identify the colour or region of the spectrum of this light? Emphasise the need to work in SI units. The wavelength is expressed in metres, the frequency in hertz, and the energy difference in joules. You may wish to show how to convert between joules and electronvolts.  **Discussion:** **Distinguishing quantisation and continuity** The difference between the quantum theory and the classical theory is similar to the difference between using bottles of water (quantum) or water from a tap (classical). The bottles represent the quantum idea and the continuous flow from the tap represents the classical theory. The quantisation of energy is also rather like the kangaroo motion of a car when you first learn to drive – it jumps from one energy state to another, there is no smooth acceleration. It is all a question of scale. We do not 'see' quantum effects generally in everyday life because of the very small value of Planck's constant. Think about a person and an ant walking across a gravelled path. The size of the individual pieces of gravel may seem small to us but they are giant boulders to the ant.  We know that the photons emitted by a light bulb, for example, travel at the speed of light (3×10^8 ms^{-1}) so why don't we feel them as they hit us? (Although all energy is quantised we are not aware of this in everyday life because of the very small value of Planck's constant.) Learners may worry about the exact nature of photons. It may help if you give them this quotation from Einstein: *'All the fifty years of conscious brooding have brought me no closer to the answer to the question, "What are light quanta?" Of course, today every rascal thinks he knows the answer, but he is deluding himself.'* **Worked example: Photon flux** Calculate the number of quanta of radiation being emitted by a light source. Consider a green 100 W light. For green light the wavelength is about 6×10^{-7} m and so: Energy of a photon: $E = hf = \frac{hc}{\lambda} = 3.3 \times 10^{-19}$ J The number of quanta emitted per second by the light: $N = \frac{P}{E} = \frac{100}{3{,}3 \times 10^{-19}} = 3 \times 10^{20}$ s^{-1} **Learner calculations: Photon flux** Worksheet 2: Photons streaming from a lamp (Resource 6) Worksheet 3: Quanta (Resource 6)

CAPS concepts, practical activities and assessment tasks	Additional information and enrichment activities
Weeks 7–8: Chemical reactions and the chemical industry	
	Worksheet 4: Chemical industries (Resource 6) Adapted from the Chemical Industries Resource Pack, developed at UCT and published under Creative Commons copyright http://open.uct.ac.za/handle/11427/7445 See this site for animations, posters and short online quizzes too.
Weeks 9–11: Preliminary examinations	
Revision	

Poster: The emission of light from an atom

(Adapted from TAP 501-1)



6. Additional worksheets with memorandums for Term 3

Worksheet 1 Photoelectric effect

(Adapted from TAP 502-2: Photoelectric effect)

$hf = W_o + \frac{1}{2}mv^2$ and $hf = W_o + eV_s$

$e = 1{,}60 \times 10^{-19}$ C

$h = 6{,}63 \times 10^{-34}$ J·s

mass of electron = $9{,}11 \times 10^{-31}$ kg

1. The work function for lithium is $4{,}6 \times 10^{-19}$ J.
   - 1.1 Calculate the lowest frequency of light that will cause photoelectric emission.
   - 1.2 What is the maximum energy of the electrons emitted when light of $7{,}3 \times 10^{14}$ Hz is used?

2. Complete the table.

Metal	Work function (eV)	Work function (J)	Frequency used (Hz)	Maximum kinetic energy of ejected electrons (J)
Sodium	2,28		6×10^{14}	
Potassium		$3{,}68 \times 10^{-19}$		$3{,}2 \times 10^{-20}$
Lithium	2,9		1×10^{15}	
Aluminium	4,1			$3{,}5 \times 10^{-20}$
Zinc	4,3			$1{,}12 \times 10^{-19}$
Copper		$7{,}36 \times 10^{-19}$	1×10^{15}	

3. The stopping potential when a frequency of $1{,}61 \times 10^{15}$ Hz is shone on a metal is 3 V.
   - 3.1 What energy is transferred by each photon?
   - 3.2 Calculate the work function of the metal.
   - 3.3 What is the maximum speed of the ejected electrons?

4. Selenium has a work function of 5,11 eV. What frequency of light would just eject electrons? (The threshold frequency is when the max kinetic energy of the ejected electrons is zero.)

5. A frequency of $2{,}4 \times 10^{15}$ Hz is used on magnesium with work function of 3,7 eV.
   - 5.1 What is the energy transferred by each photon?
   - 5.2 Calculate the maximum kinetic energy of the ejected electrons.
   - 5.3 Calculate the maximum speed of the electrons.
   - 5.4 Calculate the stopping potential for the electrons.

Answers for Worksheet 1

1. 1.1 $hf = W_o$

$6{,}63 \times 10^{-34}.f = 4{,}60 \times 10^{-19}$

$f = 4{,}60 \times 10^{-19} \div 6{,}63 \times 10^{-34}$

$= 6{,}94 \times 10^{14}$ Hz

1.2 $hf = W_o + E_k$

$(6{,}63 \times 10^{-34} \times 7{,}30 \times 10^{14}) = 4{,}60 \times 10^{-19} + E_k$

$4{,}84 \times 10^{-19} - 4{,}60 \times 10^{-19} = E_k$

$E_k = 2{,}4 \times 10^{-20}$ J

2.

Metal	Work function (eV)	Work function (J)	Frequency used (Hz)	Maximum kinetic energy of ejected electrons (J)
Sodium	2,28	**$3{,}65 \times 10^{-19}$**	6×10^{14}	**$3{,}28 \times 10^{-20}$**
Potassium	**2,30**	$3{,}68 \times 10^{-19}$	**$6{,}03 \times 10^{14}$**	$3{,}2 \times 10^{-20}$
Lithium	2,90	**$4{,}64 \times 10^{-19}$**	1×10^{15}	**$1{,}99 \times 10^{-19}$**
Aluminium	4,10	**$6{,}56 \times 10^{-19}$**	**$1{,}04 \times 10^{15}$**	$0{,}35 \times 10^{-20}$
Zinc	4,30	**$6{,}88 \times 10^{-19}$**	**$1{,}21 \times 10^{15}$**	$1{,}12 \times 10^{-19}$
Copper	**4,60**	$7{,}36 \times 10^{-19}$	1×10^{15}	**0**

For copper 1×10^{15} Hz is below the threshold frequency so no electrons are ejected.

3. 3.1 $E = hf = (6{,}63 \times 10^{-34})(1{,}61 \times 10^{15}) = 1{,}07 \times 10^{-18}$ J

3.2 Stopping potential $= E_k = (3)(1{,}6 \times 10^{-19}) = 5{,}9 \times 10^{-19}$ J

$hf = W_o + E_k$

$1{,}07 \times 10^{-18} = W_o + 5{,}9 \times 10^{-19}$

$W_o = 1{,}07 \times 10^{-18} - 5{,}9 \times 10^{-19}$

$= 4{,}77 \times 10^{-19}$ J

3.3 $E_k = \frac{1}{2}mv^2$

$5{,}9 \times 10^{-19} = 0{,}5\ (9{,}11 \times 10^{-31})\ v^2$

$v^2 = 1{,}30 \times 10^{12}$

$v = 1{,}14 \times 10^6\ m{\cdot}s^{-1}$

4. $W_o = hf = (5{,}11)(1{,}6 \times 10^{-19}) = 8{,}18 \times 10^{-19}$ J

$f = 8{,}18 \times 10^{-19} \div 6{,}63 \times 10^{-34} = 1{,}23 \times 10^{12}$ Hz

5. 5.1 $E = hf = (6{,}63 \times 10^{-34})(2{,}4 \times 10^{15}) = 1{,}59 \times 10^{-18}$ J

5.2 $W_o = 3{,}7\text{eV} = (3{,}7)(1{,}6 \times 10^{-19}) = 5{,}92 \times 10^{-19}$ J

$E = W_o + E_k$

$1{,}59 \times 10^{-18} = 5{,}92 \times 10^{-19} + E_k$

$E_k = 1{,}59 \times 10^{-18} - 5{,}92 \times 10^{-19}$

$= 9{,}99 \times 10^{-19}$ J

5.3 $E_k = \frac{1}{2}mv^2$

$9{,}99 \times 10^{-19} = \frac{1}{2}\ (9{,}11 \times 10^{-31})v^2$

$v^2 = (9{,}99 \times 10^{-19})(2) \div (9{,}11 \times 10^{-31})$

$= 2{,}19 \times 10^{12}$

$v = 1{,}48 \times 10^6\ m{\cdot}s^{-1}$

5.4 Stopping potential $= eV_s = E_{k\ max}$

$eV_s = 9{,}99 \times 10^{-19}$

$(1{,}6 \times 10^{-19})V_s = 9{,}99 \times 10^{-19}$

$V_s = 9{,}99 \times 10^{-19} \div 1{,}6 \times 10^{-19}$

$= 6{,}25$V

Worksheet 2 Photons streaming from a lamp

(Adapted from TAP 501-2)

What to do

Complete the questions below on the sheet. Provide clear statements of what you are estimating; show what calculations you are performing and how these give the answers you quote. Try to show a clear line of thinking through each stage.

Steps in the calculation

1. Give the power of a reading lamp in watts.
2. Estimate the average wavelength of a visible photon.
3. Calculate the energy transferred by each photon.
4. Calculate the number of photons emitted by the lamp in each second.

Practical advice

This question, or a substitute for it, needs to come early on in the discussion of photons to avert questions concerning our inability to be aware of single photons. However, single photon detectors are now used in astronomy and other fields.

Answers for Worksheet 2

1. $P = 40$ W (So the light emits 40 J of energy per second. Note this is not the energy of one photon.)

2. $\lambda = 5 \times 10^{-7}$ m ($\lambda_{red} = 6{,}8 \times 10^{-7}$ m and $\lambda_{violet} = 4{,}1 \times 10^{-7}$ m)

3. Calculate the frequency of the photons corresponding to this wavelength:

   $$f = \frac{c}{\lambda}$$
   $$= \frac{3 \times 10^{8}\ \text{m·s}^{-1}}{5 \times 10^{-7}\ \text{m}}$$
   $$= 6 \times 10^{14}\ \text{Hz}$$

   Now calculate the energy of each photon:

   $$E = hf$$
   $$= (6{,}63 \times 10^{-34})\ (6 \times 10^{14})$$
   $$= 3{,}98 \times 10^{-19}\ \text{J}$$

4. In 1 second, average energy of lamp = 40 J

   $E_{photon} = 3{,}98 \times 10^{-19}$ J

   Number of photons emitted in 1s

   = Average energy of lamp ÷ E_{photon}

   $= 40 \div 3{,}98 \times 10^{-19}$

   $= 1{,}01 \times 10^{20}$ photons in 1s

Worksheet 3 Quanta

(Adapted from TAP 501–3)

Speed of electromagnetic radiation in free space (c) = $3{,}00 \times 10^{8}$ m·s^{-1}

Planck's constant (h) = $6{,}63 \times 10^{-34}$ J·s

1. Write down the equation for the quantum energy of a photon in terms of its frequency.

2. Calculate the energies of a quantum of electromagnetic radiation of the following wavelengths:
   - 2.1 gamma rays, wavelength: 10^{-3} nm
   - 2.2 X-rays, wavelength: 0.1 nm
   - 2.3 violet light, wavelength: 420 nm
   - 2.4 yellow light, wavelength: 600 nm
   - 2.5 red light, wavelength: 700 nm
   - 2.6 microwaves, wavelength: 2,00 cm
   - 2.7 radio waves, wavelength: 254 m

3. Calculate the wavelengths of quanta of electromagnetic radiation with the following energies:
   - 3.1 $6{,}63 \times 10^{-19}$ J
   - 3.2 $9{,}47 \times 10^{-25}$ J
   - 3.3 $1{,}33 \times 10^{-18}$ J
   - 3.4 $3{,}98 \times 10^{-20}$ J

Practical advice

Learners may need to be reminded that a wavelength of 10^{-3} nm = 1×10^{-12} m and some learners may need help in using their calculators.

Answers for Worksheet 3

1. $E = hf$

2. 2.1 $f = \frac{c}{\lambda}$

$E = hf$

So $E = \frac{hc}{\lambda}$

$= \frac{(6{,}63 \times 10^{-34})(3{,}00 \times 10^{8})}{(1 \times 10^{-12})}$

$= 1{,}99 \times 10^{-13}$ J

2.2 $E = 1{,}99 \times 10^{-15}$ J

2.3 $E = 4{,}74 \times 10^{-19}$ J

2.4 $E = 3{,}32 \times 10^{-19}$ J

2.5 $E = 2{,}84 \times 10^{-19}$ J

2.6 $E = 9{,}95 \times 10^{-24}$ J

2.7 $E = 7{,}83 \times 10^{-28}$ J

3. 3.1 $\lambda = \frac{hc}{E}$

$\lambda = \frac{(6{,}63 \times 10^{-34})(3{,}00 \times 10^{8})}{(6{,}63 \times 10^{-19})}$

$= 3{,}00 \times 10^{-7}$ m (300 nm)

3.2 0,21 m

3.3 $1{,}5 \times 10^{-7}$ m (150 nm)

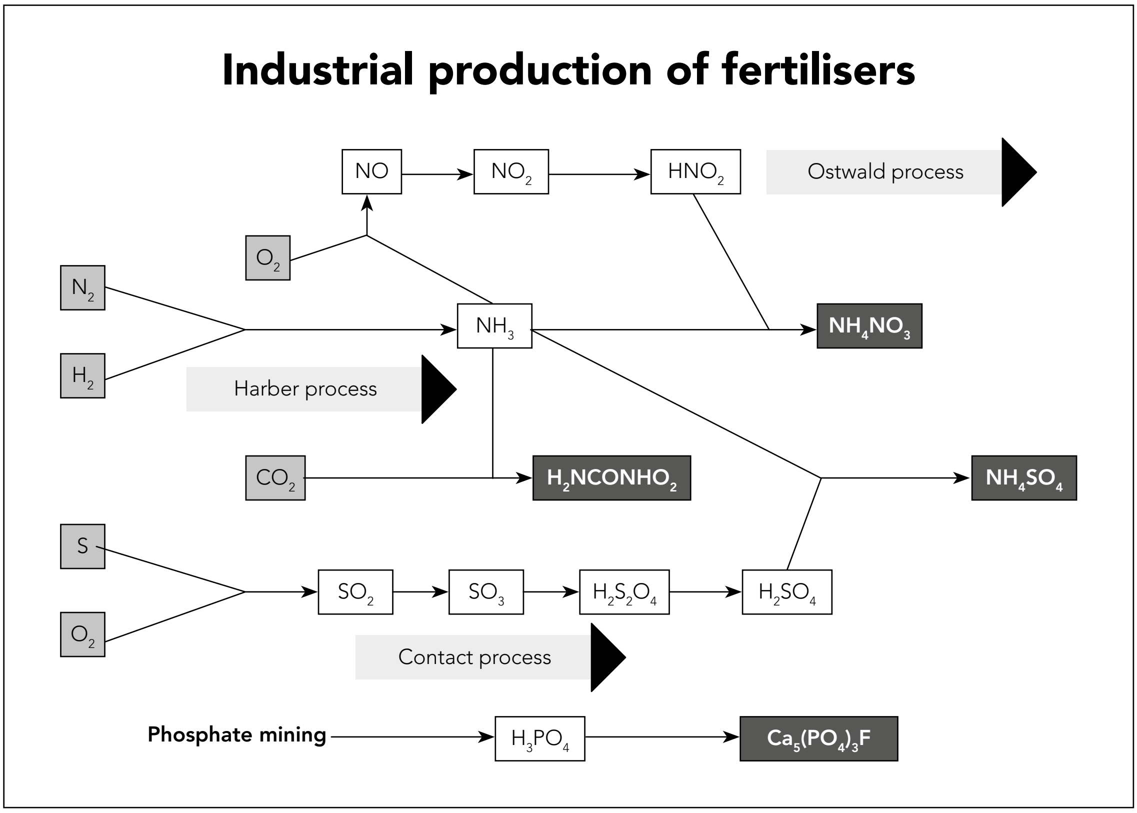
3.4 5×10^{-6} m

Worksheet 4 Chemical industries (fertilisers)

Learner's Copy

(Adapted from Chemical Industries Resource Pack – UCT Chemical Engineering Department)

Fertilisers

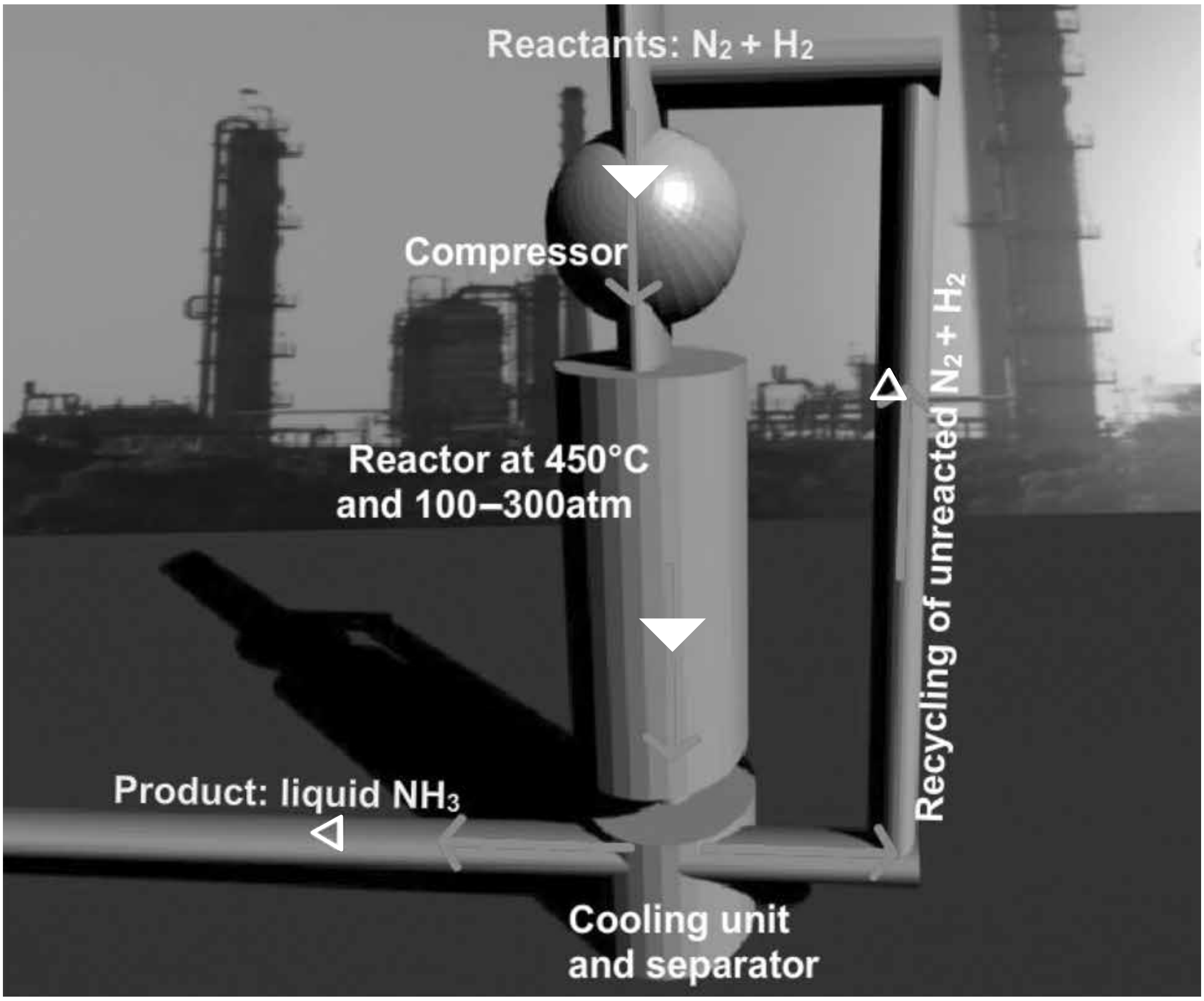


Overview

1. Why is nitrogen important to plants?
2. In what forms can plants absorb nitrogen?
3. Summarise the industrial processes by filling in the correct chemical formulae:

Process	Reactants	Products of step 1	Products of step 2	Final products
Haber		Not applicable		
Ostwald				
Contact				

Haber Process



4. What is the purpose of the Haber Process?
   To produce ____
   from ______________________ and ____________________________ .

5. Write a balanced equation for the Haber Process's reversible reaction:
   __________ + __________ $\leftrightarrows$ ________

6. Name some uses of ammonia.

7. Name two conditions that must be met for a reaction to reach equilibrium.

8. Name two characteristics of equilibrium.

9. In the Haber Process an iron oxide catalyst is usually used. Ruthenium can also be used. What does a catalyst do in a reaction, and how does it do this?

10. Circle the correct option (True/False) for each of the following:

a) A catalyst speeds up the Haber Process's forward reaction more than the reverse.
[True/False]

b) A catalyst will cause more product to be formed.
[True/False]

c) A catalyst will decrease the time it takes to reach equilibrium because it speeds up both forward and reverse reactions.
[True/False]

d) A catalyst speeds both forward and reverse reactions equally.
[True/False]

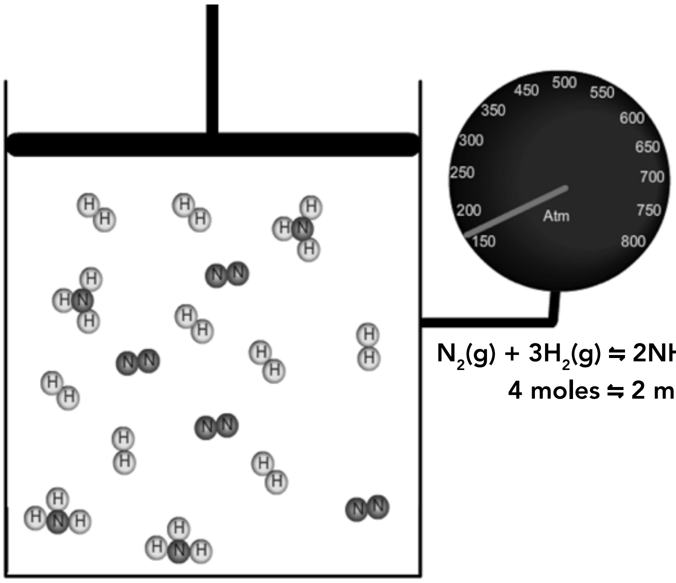
11. Link each element from column A with its corresponding element in column B.
Write the letter from A next to each item in B in the Answer column.

A	B	Answer
a) dynamic equilibrium	absorbs more heat than released	11.1
b) endothermic	a measure of the average kinetic energy of particles	11.2
c) exothermic	disturbs equilibrium, favours increased crowding: more molecules per unit volume	11.3
d) Le Chatelier's principle	273 K and 101,3 kPa	11.4
e) decrease in pressure	disturbs equilibrium, favours exothermic reaction	11.5
f) increase in pressure	releases more heat than absorbed	11.6
g) removing heat	a state in which forward and reverse reactions occur at equal rates	11.7
h) adding heat	force per area, in gases related to rate of particle collisions	11.8
i) temperature	disturbs equilibrium, favours decreased crowding, fewer molecules per unit volume	11.9
j) pressure	disturbs equilibrium, favours endothermic reaction	11.10
k) STP	when a system which is in equilibrium is disturbed, it will respond in such a way as to counteract the disturbance	11.11

Le Chatelier: Effect of pressure in the Haber Process

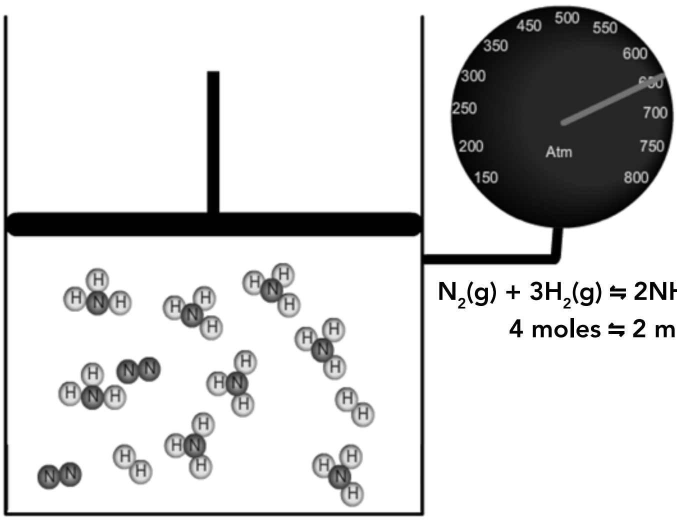
12. Study the diagrams below representing the same container and gases under different pressure at the same temperature.

Condition 1



$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
4 moles ⇋ 2 moles

Condition 2



$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
4 moles ⇋ 2 moles

Complete the explanation by filling in the gaps or choosing from the options given.

12.1 **Increased pressure**

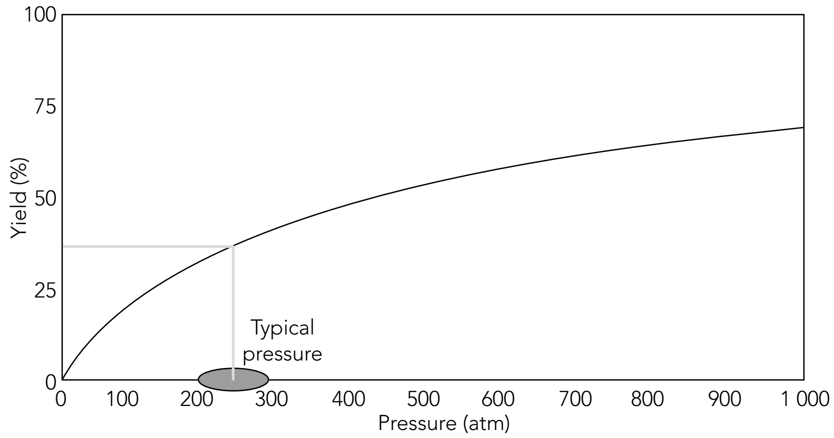
According to **a)** ______________________________ principle, when a system which is in equilibrium is disturbed, it will respond in such a way as to **b)** ______________________________ the disturbance. An increase in pressure **[c) decreases/increases]** the crowding of gaseous molecules. The system will respond by **[d) decreasing/increasing]** their crowding. Crowding is decreased in gases when **[e) fewer/more]** molecules are formed. In the Haber Process the **[f) forward/reverse]** reaction makes fewer molecules than the **[g) forward/reverse]** reaction. In the forward reaction, **h)** ___________ molecules of ammonia are made from every **i)** ___________ molecules of reactants,

j) ___________ N_2 and **k)** ___________ H_2 molecules). Consequently, an increase in pressure **l)** _______________________________ equilibrium for a while by making the **[m) forward/reverse]** reaction occur at a higher rate than the **[n) forward/reverse]** reaction. This causes **[o) more/less]** ammonia to be formed and **[p) more/less]** nitrogen and hydrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again **q)** _______________________________ to one another, and the amounts of reactants and products will **[r) change/remain constant]**. However, compared to before the pressure was applied, there will now be **[s) more/less]** ammonia present at equilibrium. The equilibrium constant value, Kc, however, will be **[t) higher than/lower than/the same as]** it was in the original equilibrium.

12.2 **Decreased pressure**

Decreasing pressure **[a) decreases/increases]** the crowding of gaseous molecules. The system will respond by **[b) decreasing/increasing]** their crowding. Crowding can be increased by forming **[c) fewer/more]** molecules. In the Haber Process, that means that for a while the **[d) forward/reverse]** reaction will occur at a higher rate than the **[e) forward/reverse]** reaction. The reverse reaction changes every **f)** ___________ molecules of ammonia into **g)** _______________________________ molecules (**h)** ___________ nitrogen and **i)** ___________ hydrogen molecules). This causes the amount of ammonia present to **[j) decrease/increase]** and the amount of nitrogen and hydrogen to **[k) decrease/increase]**. While this is happening the system **[l) is/is not]** in equilibrium. After a while a new dynamic equilibrium will be reached, in which the rates of both forward and reverse reactions will **m)** _______________________________ one another, and the amounts of reactants and products will remain **n)** _______________________________. However, compared to before the pressure was decreased, there will now be **[o) more/less]** ammonia present at equilibrium. The equilibrium constant value, Kc, however, will be **[p) higher than/lower than/the same as]** it was in the original equilibrium.

Study the graph representing the different yields of ammonia under different pressures.



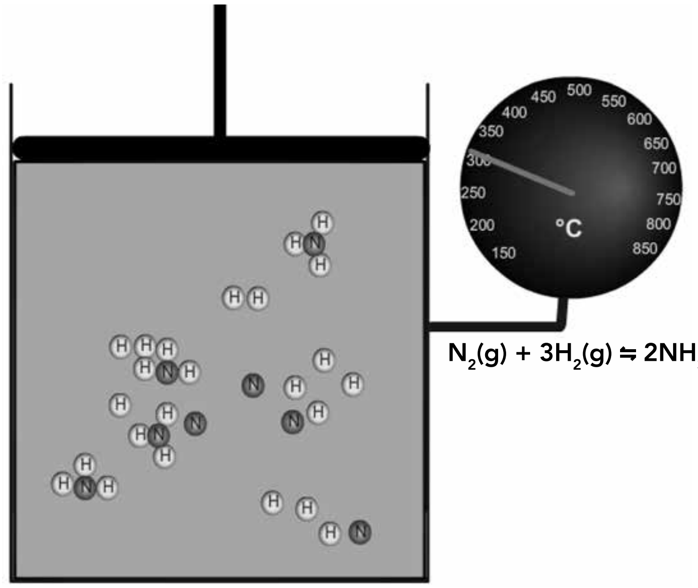
12.3 **Optimum pressure in the Haber Process**

In the Haber Process, we want to make as much **a)** _______________________________ as possible. We want the dynamic equilibrium to be such that a lot of **[b) reactant/product]** is formed. A(n) **[c) decrease/increase]** in pressure will cause more products to form. We need as **[d) low/high]** a pressure as it is safe and economical to use. We say we need to use an **e)** _______________________________ pressure – the pressure for which we get a good yield for a reasonable price while still being safe. Even though a high pressure will increase the yield of ammonia, the cost of compressing the gases and the cost of ultra-high pressure reactors are very high and are not a viable solution for making ammonia. Pressures of 200–300 atmospheres are typically used in chemical factories using the Haber Process.

Le Chatelier: Effect of temperature in the Haber Process

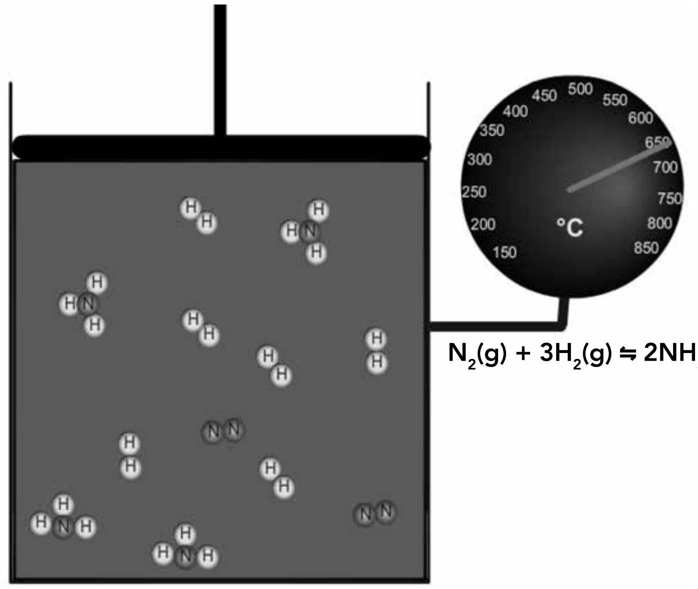
13. Study the diagrams below representing the same container and gases under different temperatures at the same pressure.

Condition 1



$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ + energy

Condition 2



$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ + energy

Complete the explanation by filling in the gaps or choosing from the options given.

13.1 **Heating**

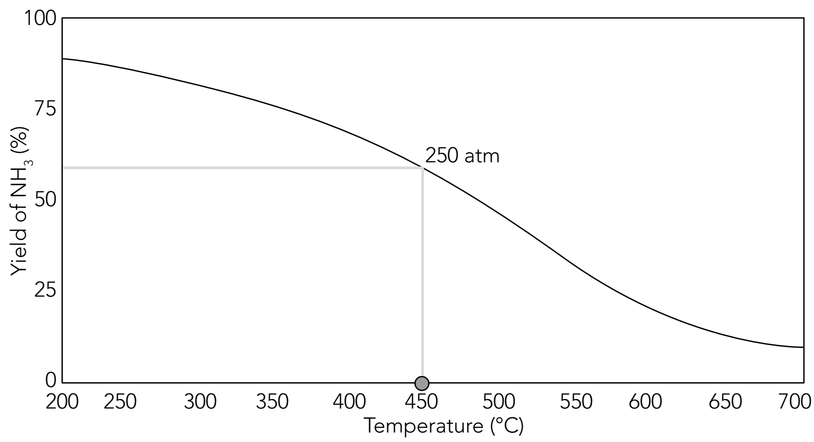
Heating a reaction up increases the **a)** ______________________________ energy of the particles, and so causes them to react more **[b) slowly/rapidly]** with one another. Additionally, heat can have an effect on disturbing the **c)** ______________________________ of a reaction. In the Haber Process the forward reaction is **[d) exothermic/endothermic]** and the reverse is **[e) exothermic/endothermic].** This means that as nitrogen and hydrogen react with one another to form ammonia, heat is **[f) absorbed/released]**, but as ammonia breaks up into hydrogen and nitrogen, heat is **[g) absorbed/released].** According to Le Chatelier's principle, when a system which is in equilibrium is disturbed, it will respond in such a way as to counteract the disturbance. So if heat is added to a system in the Haber Process, the **[h) exothermic/endothermic] [i) forward/reverse]** reaction is favoured to **[j) absorb/release]** some of that heat and so **[k) cool the system back down/heat the system back up].** Both the forward and reverse reactions occur at **[l) lower/higher]** rates than before the heat was added, due to the additional kinetic energy of all the particles, but the **[m) forward/reverse]** reaction will have been speeded up to a greater extent than the **[n) forward/reverse]** reaction. So for a while, the system will not be in **o)** ______________________________ as the **[p) forward/reverse]** reaction occurs more rapidly than the **[q) forward/reverse]** reaction. This will **[r) increase/decrease]** the amount of ammonia present, and **[s) increase/decrease]** the amount of hydrogen and nitrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again **t)** ______________________________ to one another, and the amounts of reactants and products will remain **u)** ______________________________. However, compared to before the heat was added, there will now be **[v) less/more]** ammonia present at equilibrium. A new equilibrium constant, Kc, **[w) higher than/lower than/the same as]** that of the original equilibrium, is reached.

13.2 **Cooling**

Cooling a system that is in equilibrium has two effects. Firstly, by **[a) decreasing/increasing]** the kinetic energy of all the molecules, it **[b) reduces/increases]** the rates of both the forward and reverse reactions. Secondly, it has the effect of disturbing the **c)** ______________________________ by favouring the **[d) exothermic/endothermic]** reaction until a new equilibrium is reached with **[e) the same/a different]** equilibrium constant.

If heat is removed from a system in the Haber Process, the **[f) exothermic/endothermic] [g) forward/reverse]** reaction is favoured to **[h) cool the system back down/heat the system back up].** For a while, the system will not be in **i)** ______________________________ as the **[j) forward/reverse]** reaction occurs more rapidly than the **[k) forward/reverse]** reaction. This will **[l) increase/decrease]** the amount of ammonia present, and **[m) increase/decrease]** the amount of hydrogen and nitrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again **n)** ______________________________ to one another, and the amounts of reactants and products will remain **o)** ______________________________. However, compared to before the system was cooled, there will now be **[p) less/more]** ammonia present at equilibrium. A new equilibrium constant, Kc, **[q) higher than/lower than/the same as]** that of the original equilibrium, is reached.

Study the graph representing the different yields of ammonia under different temperatures.



13.3 **Optimum temperature**

In the Haber Process, we want to get a high ammonia yield. We want a dynamic equilibrium which makes as much ammonia product as possible. Consequently, we need to use a fairly **[a) high/low]** temperature. However, this causes a problem, namely **b)** ______________________________. Therefore, a compromise is made, and a temperature of approximately 450°C is often used.

Units of pressure and temperature

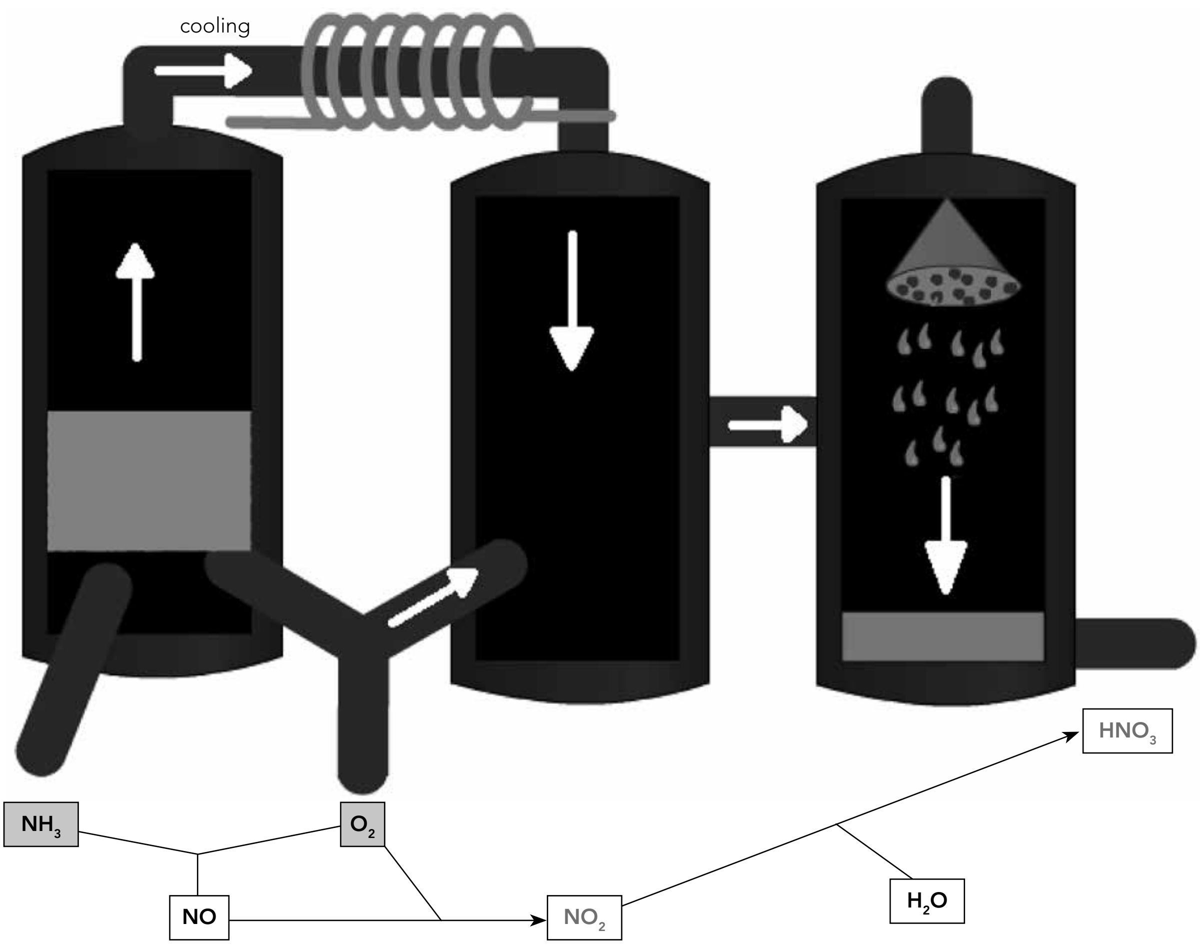
14. Complete for units of pressure:

Unit		Pressure at sea level at 0 °C
Name	Symbol	
Bar		
	atm	
		101,3 kPa
		760 mm Hg

15. Kelvin is the SI (Standard International) unit for temperature. Complete for conversions:

Temperature in degrees Celsius (°C)	Temperature in Kelvin (K)
0	
	0
100	
	200
25	

Ostwald Process



16. What is the purpose of the Ostwald Process?

To produce ______________________________ from ______________________________.

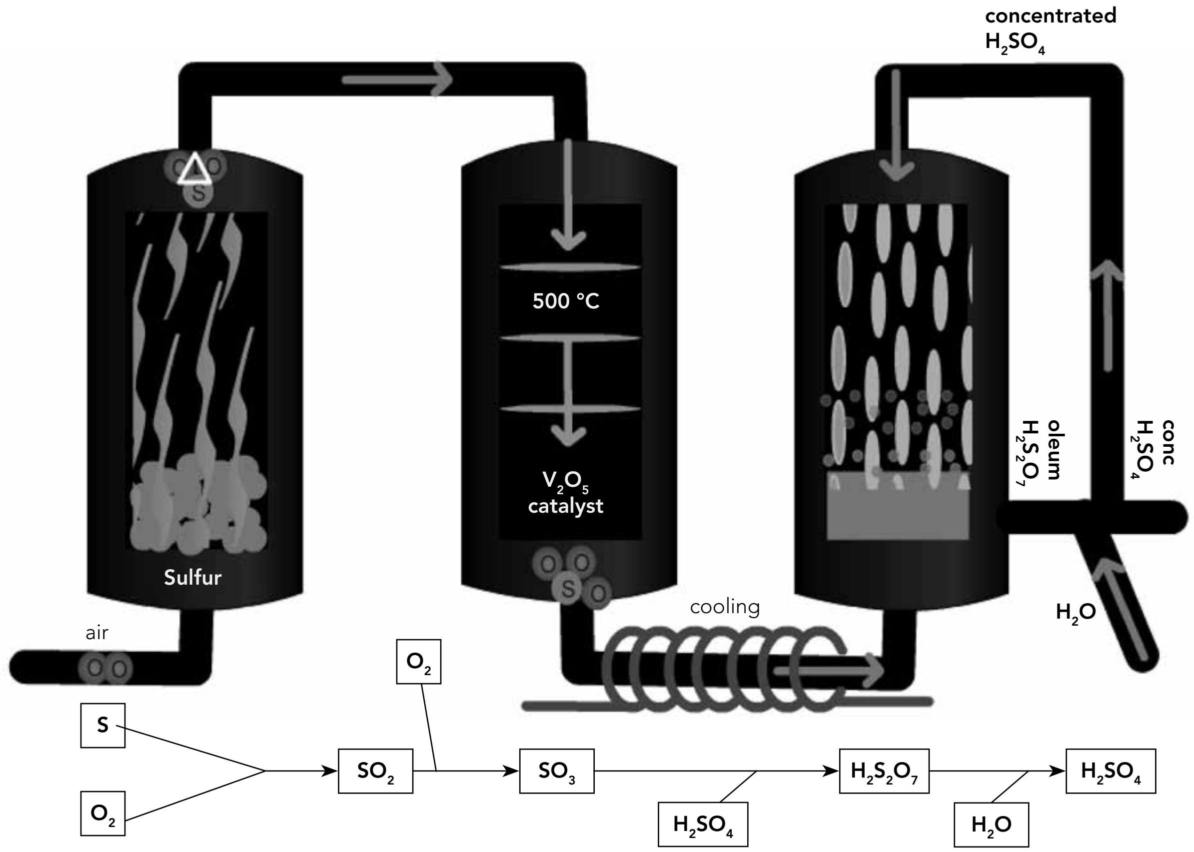
17. How is the product of the Ostwald Process useful for the fertiliser industry?

18. Why doesn't it matter that the platinum catalyst used is very expensive?

19. Complete the table by filling in the chemical formulae of the substances in the Ostwald Process:

Step 1	Step 2	Step 3
____________ + ____________ catalyst ________________________	____________ + ____________ ________________________	____________ + ____________ ________________________

Contact Process



20. What is the purpose of the Contact Process?

To produce ______________________________ from ______________________________.

21. Name some uses of sulfuric acid.

22. Complete the table by filling in the **balanced** chemical equations for the Contact Process:

Step 1	Step 2	Step 3	Step 4
________ + ________ ____________________	________ + ________ catalyst ____________________	________ + ________ ____________________	________ + ________ ____________________

Answers for Worksheet 4

1. Nitrogen is found in all proteins, and so it is an essential nutrient.
2. Dissolved urea, nitrate, nitrite and ammonium ions.
3.

Process	Reactants	Products of step 1	Products of step 2	Final products
Haber	$N_2 + H_2$	Not applicable		NH_3
Ostwald	$NH_3 + O_2$	NO	NO_2	HNO_3
Contact	$S + O_2$	SO_2	SO_3	H_2SO_4

4. To produce ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2)
5. $N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g)$
6. As a cleaning agent; as a coolant in some air conditioners; to manufacture nitrogen fertilisers.
7. Reversible reaction, closed system.
8. Rates of forward and reverse reactions are equal to one another.
   The concentrations of reactants and products remain constant.
9. It speeds up a reaction by lowering its activation energy. It does this by serving as a binding site on which the reaction can occur.
10. a) False
    b) False
    c) True
    d) True
11. 11.1 b
    11.2 i
    11.3 e
    11.4 k
    11.5 g
    11.6 c
    11.7 a
    11.8 j
    11.9 f
    11.10 h
    11.11 d
12. 12.1 a) Le Chatelier's
    b) counteract
    c) increases
    d) decreasing
    e) fewer
    f) forward
    g) reverse
    h) 2
    i) 4
    j) 1
    k) 3
    l) disturbs
    m) forward
    n) reverse
    o) more
    p) less
    q) equal
    r) remain constant
    s) more
    t) the same as

12.2 a) decreases
b) increasing
c) more
d) reverse
e) forward
f) 2
g) 4
h) 1
i) 3
j) decrease
k) increase
l) is not
m) equal
n) constant
o) less
p) the same as

12.3 a) ammonia
b) product
c) increase
d) high
e) optimal

13. 13.1 a) kinetic
b) rapidly
c) equilibrium
d) exothermic
e) endothermic
f) released
g) absorbed
h) endothermic
i) reverse
j) absorb
k) cool the system back down
l) higher
m) reverse
n) forward
o) equilibrium
p) reverse
q) forward
r) decrease
s) increase
t) equal
u) constant
v) less
w) lower than

13.2 a) decreasing
b) reduces
c) equilibrium
d) exothermic
e) a different
f) exothermic
g) forward
h) heat the system back up
i) equilibrium
j) forward
k) reverse
l) increase

m) decrease
n) equal
o) constant
p) more
q) higher than

13.3 a) low
b) it causes both reactions to be slow, and so it takes a long time for equilibrium to be reached

14.

Unit		Pressure at sea level at 0 °C
Name	Symbol	
Bar	bar	**1 bar**
Atmospheres	atm	**1 atm**
Kilopascals	**kPa**	101,3 kPa
millimetres mercury	**mm Hg**	760 mm Hg

15.

Temperature in degrees Celsius (°C)	Temperature in Kelvin (K)
0	**273**
–273	0
100	**373**
–27	200
25	**298**

16. To produce nitric acid (HNO_3) from ammonia (NH_3)
17. Nitric acid can be used to make nitrate fertilisers.
18. It can be used over and over again because it is not used up. Catalysts speed up reactions without themselves being changed in the process.
19.

Step 1	Step 2	Step 3
$NH_3 + O_2$ $\downarrow$ Pt catalyst NO	$NO + O_2$ $\downarrow$ NO_2	$NO_2 + H_2O$ $\downarrow$ HNO_3

20. To produce sulfuric acid (H_2SO_4) from sulfur (S) and oxygen (O_2)
21. Manufacture of fertilisers; electrolyte in car batteries; as a dehydrating (drying) agent.
22.

Step 1	Step 2	Step 3	Step 4
$S + O_2$ $\downarrow$ SO_2	$2\,SO_2 + O_2$ $\downarrow$ V_2O_5 catalyst $2SO_3$	$SO_3 + H_2SO_4$ $\downarrow$ $H_2S_2O_7$	$H_2S_2O_7 + H_2O$ $\downarrow$ $2H_2SO_4$

7. The exemplar worksheet for the physics experiment on electric circuits

A data sheet is provided for reference.

Question 1

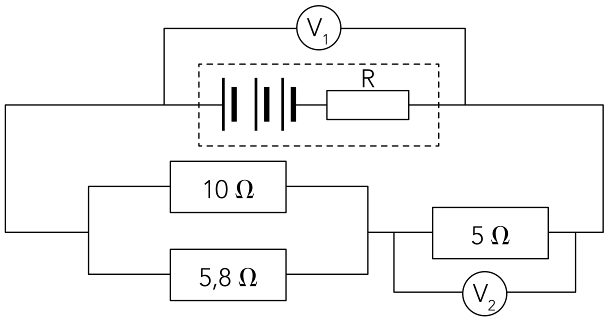
A battery consists of three cells, each of emf 1,5 V and internal resistance 0,5 Ω, connected in series.

1.1 Explain what is meant by 'a cell has an emf of 1,5 V'. (3)

1.2 Calculate the emf of the battery. (2)

1.3 Calculate the total internal resistance R of the battery. (2)

The circuit diagram below shows this battery connected to a combination of resistors. Two resistors of 10 Ω and 5,8 Ω are connected in parallel with each other, and the parallel combination is connected in series to a 5 Ω resistor.



1.4 Determine the total resistance of the external circuit. (5)

1.5 Calculate the current through the battery. (5)

1.6 Calculate the reading on voltmeter V_1. (3)

1.7 If the 5,8 Ω resistor is removed from the circuit how are the following values affected? Justify your answers with a calculation.

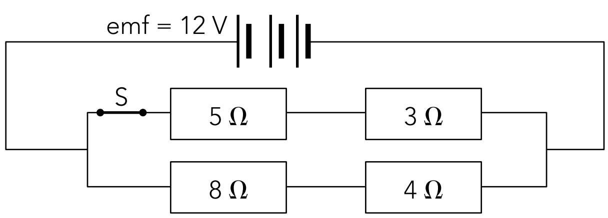
a) The current through the battery (5)

b) The voltage reading on the voltmeter V_1 (3)

[28]

Question 2

The battery in the circuit shown below has an emf of 12 V and negligible internal resistance. It is connected to a network of four resistors.



2.1 Determine the current through the 5 Ω and 3 Ω resistors. (2)

2.2 Determine the current through the 8 Ω and 4 Ω resistors. (2)

2.3 Determine the total resistance of all the resistors in the circuit. (2)

2.4 Explain how the total resistance of the circuit changes when switch S is opened. (3)

2.5 Explain how the current changes when switch S is opened. (3)

[12]

TIME: 30 MINUTES

TOTAL MARKS: 40

DATA SHEET FOR USE WITH THE WORKSHEET ON ELECTRIC CIRCUITS

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Magnitude of charge on electron	e	$1,6 \times 10^{-19}$ C
Mass of an electron	m_e	$9,1 \times 10^{-31}$ kg

TABLE 2: PHYSICS FORMULAE
ELECTRIC CIRCUITS

$I = \frac{q}{t}$	$V = \frac{W}{Q}$
$R = \frac{V}{I}$	$emf = I(R_{ext} + r)$
$R_T = R_1 + R_2 + \ldots$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
$W = Pt$	$P = VI = I^2R = \frac{V_2}{I}$

8. Memorandum for the worksheet for the physics experiment on electric circuits

Question 1

1.1 An emf of 1,5 V tells us that a total energy ✓ of 1,5 J is transferred by the cell ✓ per coulomb of charge which passes through it. ✓ (3)

1.2 emf = 3 × 1,5 ✓
= 4,5 V ✓ (2)

1.3 R = 0,5 + 0,5 + 0,5 ✓
= 1,5 Ω ✓ (2)

1.4 $\frac{1}{R} = \frac{1}{10}$ ✓ + $\frac{1}{5{,}8}$ ✓
R = 3,67 Ω ✓
$R_{external}$ = 3,67 + 5 ✓ = 8,67 Ω ✓ (5)

1.5 emf = I(R + r) ✓
4,5 ✓ = I(8,67 ✓ + 1,5) ✓
I = 0,44 A ✓ (5)

1.6 V_1 = IR ✓
= (0,44)(8,67) ✓
= 3,84 V ✓ (3)

1.7 a) Current through the battery decreases ✓
R = 10 + 5 = 15 Ω ✓
Emf = I(R + r ✓
4,5 = I(15+ 1,5) ✓
I = 0,27 A ✓ (5)

b) The reading on the voltmeter V_1 increases ✓
V = IR
= (0,27) (15) ✓
= 4,09 V ✓ (3)

[28]

Question 2

2.1 $V = IR$

$12 = I(5 + 3)$ ✓

$I = 1{,}5$ A ✓ (2)

2.2 $V = IR$

$12 = I(8 + 4)$ ✓

$I = 1$ A ✓ (2)

2.3 $R = \frac{V}{I}$ ✓

$= \frac{12}{2{,}5}$

$= 4{,}8\ \Omega$ ✓

ALTERNATIVE:

$\frac{1}{R} = \frac{1}{5+3} + \frac{1}{8+4}$ ✓

$= \frac{1}{8} + \frac{1}{12}$

$R = 4{,}8\ \Omega$ ✓ (2)

2.4 The total resistance increases ✓ when switch S is opened because there are only two resistors in series in the circuit.

$R = 8 + 4$ ✓ $= 12\ \Omega$ ✓ (3)

2.5 The current decreases ✓ when switch S is opened.

$12 = I(12)$ ✓

$I = 1$ A ✓ (3)

[12]

TOTAL MARKS: 40

9. Exemplar item analysis sheets for:

9.1 A physics examination

PHYSICS PRELIMINARY EXAMINATION

		Newton's Laws	Vertical projectile motion	Momentum & impulse	Work, energy & power	Doppler effect	Electrostatics	Electric circuits	Electrodynamics	Optical phenomena Properties of materials	Total
Topic		Mechanics				Waves, sound & light	Electricity & magnetism			Matter & materials	
Marks (target		±63				±17	±55			±15	150
Marks (actual)											
Learner name	Learner surname										

9.2 A chemistry examination

CHEMISTRY PRELIMINARY EXAMINATION

		Stoichiometry	Intermolecular forces	Organic chemistry	Energy & change Rate & extent of reactions	Chemical equilibrium	Acids & bases	Electrochemical reactions	Chemical Industry & Fertiliser Industry	Total
Topic		Matter & materials			Chemical change				Chemical systems	
Marks (target		±48			±84				±18	150
Marks (actual)										
Learner name	Learner surname									

9.3 An experiment

PRACTICAL ASSESSMENT DETERMINE THE INTERNAL RESISTANCE OF A CELL (BATTERY)								
		Practical skills and questions						
		1	2	3	4	5	6	Total
		Pre-practical preparation	Setting up equipment Conducting experiment	Collection of data	Tabulation and calculations	Discussion of results and conclusion	Questions	
Marks (target								
Marks (actual)							40	
Learner name	Learner surname							

10. Templates for tracking, reflecting on and reporting curriculum coverage

10.1 Conventional schools[1]

NAME OF TEACHER:____ **SUBJECT/GRADE:**________

Week no. in planner _______________

Week no. in term when work planned for week started _______________

Refer to the planner[2] for details of the week's work (or the ATP for subjects without planners)

Class (or subject for FP)				
On track by end of week? (Yes/no)				
How many learners are working confidently?[3] (Rough estimate)				
How many learners in this class?				

DAY[4]	**BRIEF NOTES ON THE DAY'S WORK: Consider such things as:** *What concepts/skills did the learners struggle with or manage well in this lesson?* *What could be the reasons for this? Did the class complete the work you had planned?* *Do you need to change your plans for the next lesson? What changes will you make?*
1	
2	
3	
4	
5	

Reflection on the week: Think about and make a note of:	
What concepts and skills for the week did learners struggle with? What could you do differently next time to better support or extend learning? What good practice could you share?	**Did you cover the curriculum for the week? If not, what were some of the challenges? What can you do to catch up? What help do you need? How will your progress this week affect your plan for next week?**
DH:	**Date:**

1 Please amend this draft template to suit the needs of your school.
2 You can use any planning document (such as the CAPS planner, the ATP or printed lesson plans) as the basis for your tracking.
3 Estimate of learners in that grade that are working confidently at Level 4 (adequate achievement) or above.
4 This can also be lessons if there are more than five lessons a week.

10.2 Multigrade schools[1]

NAME OF TEACHER

Week no. in planner _______________

Week no. in term when work planned for week started _______________

Refer to the planner[2] **for details of the week's work** (or the ATP for subjects without planners)

Subjects							
GRADE	On track this week? [3]						
	Est. learners > Level 4 [4]						
	# learners in grade						
GRADE	On track this week?						
	Est. learners > Level 4						
	# learners in grade						
GRADE	On track this week?						
	Est. learners > Level 4						
	# learners in grade						

DAY	**BRIEF NOTES ON THE DAY'S WORK: Consider such things as:** *What concepts/skills did the learners struggle with or manage well in this lesson? What could be the reasons for this? Did the class complete the work you had planned? Do you need to change your plans for the next lesson? What changes will you make?*
1	
2	
3	
4	
5	

Reflection on the week: Think about and make a note of:		
SUBJECT	**What concepts/skills did the learners struggle with or manage well in this lesson? What could be the reasons for this? Did the class complete the work you had planned? Do you need to change your plans for the next lesson? What changes will you make? What good practice could you share?**	**Did you cover the curriculum for the week? If not, what were some of the challenges? What can you do to catch up? What help do you need? How will your progress this week affect your plan for next week?**
Principal:		**Date:**

1 Please amend this draft template to suit the needs of your school.
2 You can use any planning document (such as the CAPS planner, the ATP or printed lesson plans) as the basis for your tracking.
3 Yes/no?
4 Estimate of learners in that grade that are working confidently at Level 4 (adequate achievement) or above.

Jika iMfundo
what I do matters

Jik'iMfundo is a programme to improve learning outcomes, funded by the National Education Collaboration Trust, the KwaZulu-Natal Department of Education and others.

THE PROGRAMME TO IMPROVE LEARNING OUTCOMES

The Shed
The Pines
9 Gordon Hill Road
Parktown
2193

Tel: +27 10 880 2431

Email: admin@pilo.co.za

ISBN: 978-1-990918-33-9